In this Issue: The Voluminosity of Engineering Literature.—Towers of the Manhattan Bridge.—Formulas for the Design of Cableways.—Changes in the Lower Colorado River.—Locomotive Coaling Plants.

ENGINEERING NEWS

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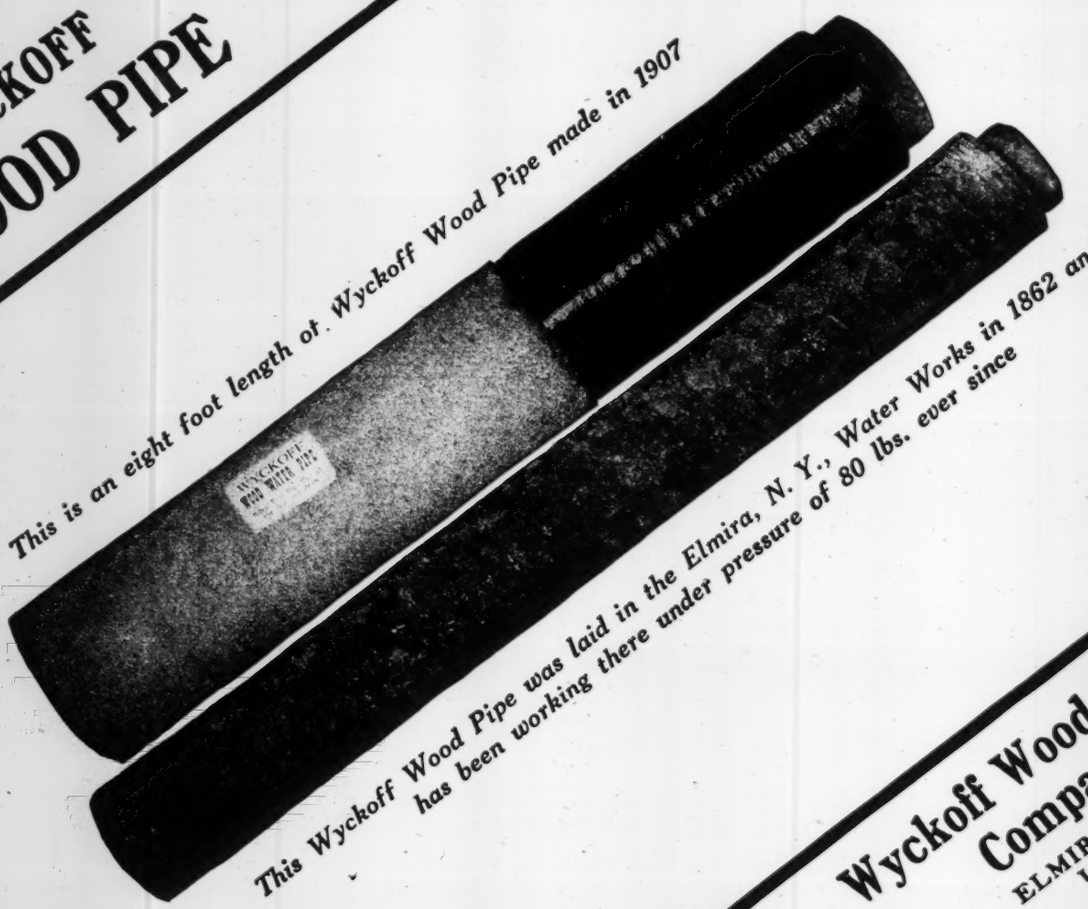

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A LARGE WOODEN TRESTLE AT McGILL, NEVADA.

By J. L. DOBBINS.*

The preparations of the Steptoe Valley Smelting & Mining Co. to handle the large daily tonnage of ore which will soon be shipped to its plant at McGill, Nev., have involved the construction of an immense approach trestle which has several unique features in its construction detail.

The whole plant of this company is located rather high up on the hillside in order that the natural fall of the ground toward the bottom land of Steptoe Valley may be utilized to carry the tailings from the concentrator away from the immediate site of the smelter, and also similarly to dispose of the large quantities of slag, which, poured molten into the stream, will be pulverized by the sudden cooling and thus become easy of transportation by the running water. The concentrator is approached by a trestle 1,672.5 ft. long and of a maximum height of 109 ft. A timber trestle comprises the first 1,212.5 ft. of this approach, and for the 380 ft. nearest the concentrator there is a viaduct of steel, the two being connected by an 80-ft. steel girder. The entire structure is double tracked; and under the floor of the steel viaduct are ore bins of 5,000 tons capacity, high up above the ground in order that the distribution of ore to the samplers and to the crushers may be accomplished by gravity chutes.

*Assistant Engineer, Nevada Northern R. R., P. O. Box 296, Ely, Nevada.

The steel viaduct with its bins thus constitutes an essential and permanent part of the concentrator itself. But the wooden approach is more temporary in its purpose, it being the ultimate intention to fill it with surface strippings from the mines above; and it was in accordance with this plan that the open space between the two structures, spanned by the 80-ft. girder, was left, in order that the steel viaduct towers might not be affected by making the embankment. This fill, however, requiring an estimated volume of about 1,700,000 cu. yds., could not be made in the manner intended until long after the approach to the ore bins was needed, and therefore the trestle had to be designed as a permanent structure to accommodate a heavy traffic.

In order to reduce the amount of timber and consequently the cost of the structure, the trestle bents were spaced 25 ft. on centers with the stringers or upper chords breaking joint at every bent. To give additional stiffness to these long span chords they were braced to the next lower stage by the trussed system shown in the half-tones, the lower chord of this truss being 12 × 12-in. struts, continuous throughout the entire trestle. Continuity of the chords was somewhat regained by the use of 6-ft. filler plates between stringers over every cap, these plates being well bolted to the stringers.

The bent design called for continuous built-up posts, thus utilizing the greater bearing power of timber with fibers end to end than that permissible where caps or sills are used with the bearing across the grain. The plumb posts are 12 × 12-in. timbers from the caps down to the panel points of the chord trussing. Below this they are built up of one 12 × 12-in. and one 6 × 12-in. stick and are continuous to the concrete foundation pedestals, additional 6 × 12-in. splice pieces being bolted on wherever the abutting joints in the 12 × 12-in. posts occur. As in most heavy timber construction, bearing became the limiting feature of the bent design, for which allowable stresses of 800 lbs. per sq. in. along the fiber and 300 lbs. per sq. in. across the fiber were used. To gain the additional surface necessary at caps and sills, corbels were used at the tops and bottoms of the posts.

The trestle was constructed with a track grade of 0.275% adverse to the loaded ore trains, 0.4% being the maximum adverse grade throughout the entire length of road from the mines to the smelter, a distance of about twenty miles. The existence of this grade will subject the structure to rather heavy tractive stresses from trains being drawn across it to the ore bins. In addition to this,

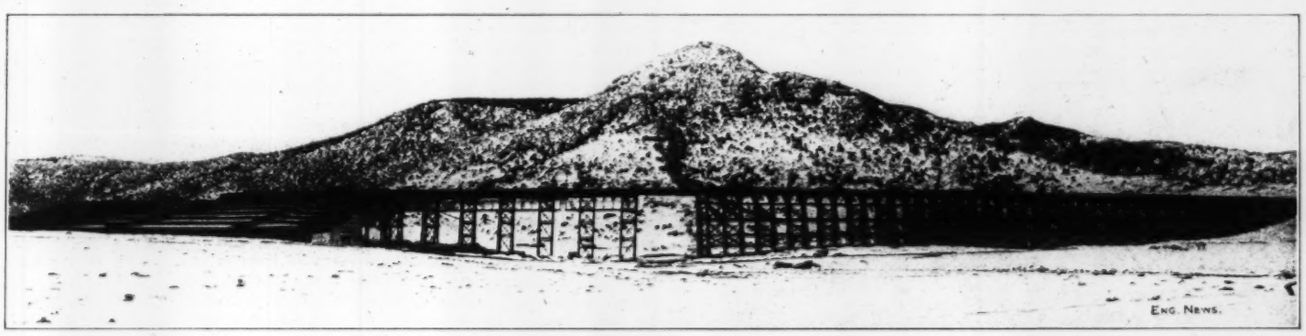


FIG. 1. TIMBER AND STEEL TRESTLE APPROACH TO A SMELTER AT McGILL, NEV.

(Plant of the Steptoe Valley Smelting & Mining Co. 1,672 ft. long; 109 ft. maximum height. Photograph by Gallagher & Gutter, Ely, Nev.)

FIG. 2. END VIEW OF THE McGILL TRESTLE.

as the ore track terminates at the bins, there will be frequent stopping and starting of trains on the trestle, thus subjecting it to maximum longitudinal stresses, as the train accelerations are greatest at the moments of starting and stopping. The full 20% tractive force of a train whose actual loading falls little below that of Cooper's E-50 had thus to be allowed for in the design of the longitudinal bracing. This was done by placing heavy diagonal bracing between alternate bents, each pair of bents thus comprising a tower similar somewhat to viaduct construction. Whether or not this method of bracing, when used in a wooden structure of such height and length, will give the desired rigidity that a continuous system of longitudinal bracing would more fully insure, is one of the points of interest which the final test of the structure by continuous use will determine. If the desired rigidity should be lacking additional bracing between the towers will be added.

The timber trestle is flanked by a 40-ft. abutment masonry retaining wall, that being the least height of the deck of the structure above the ground, its maximum being 109 ft. from sill to base of rail and the average for the entire length about 83 ft.

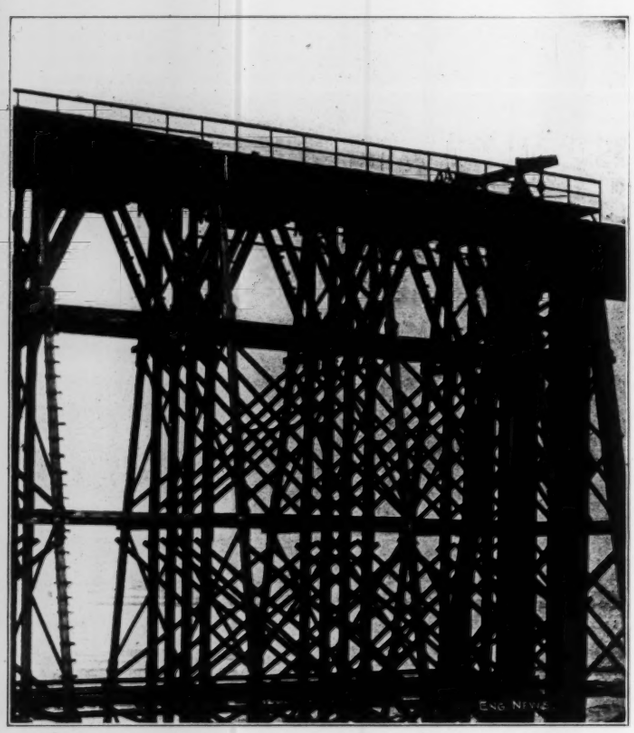


FIG. 3. NEAR VIEW OF TRESTLE, SHOWING DETAILS.

The A. Hughes Construction Company of Denver began construction of the trestle early in August, 1907, and completed it, ready for track steel, on Jan. 5, 1908. At about the same time the American Bridge Company commenced erection of the steel viaduct and at the end of February it was ready for tracks and the last details of the ore bins were being installed.

About 1,338,000 B. M. of lumber at a cost of $57 per thousand B. M. in place, and approximately 70 tons of bolts and metal connections were used in constructing the trestle and 1,460 tons of steel in the viaduct. In the foundation work, exclusive of the masonry retaining wall, at the end of the trestle, 1,760 cu. yds. of concrete were required.

The designs for both structures were drawn up by the company's engineering staff, with Mr. Rork as Chief Draftsman. The designs were begun with Mr. T. Cox as Chief Engineer and completed and erected under the supervision of his successor, Mr. S. S. Sorensen.

The structures themselves were built by the Steptoe Valley Smelting & Mining Co. as a part of its own plant, although operation over them will be conducted by the Nevada Northern R. R., an allied company, which is the connecting link between the mines of the Nevada Consolidated and Cumberland-Ely Copper Cos., higher up in the Robinson Canyon above Ely, Nev., and their smelter, located as it is at the point where an abundant supply of water is most available.

THE LOWER COLORADO RIVER DURING AND AFTER THE FRESHET STAGE OF 1907.

By C. E. GRUNSKY,* M. Am. Soc. C. E.

It will be remembered that for nearly a year after November, 1905, the main flow of Colorado River was inland to the Cahuilla (Salton) Basin; that the break in the river bank at the Lower Mexican Heading of the Imperial Canal was then closed; that a second break occurred in December, 1906, and that the river was finally restored to its proper course in February, 1907.† During the time that the river channel from the Lower Mexican Heading (see map herewith) down to the Gulf of California was receiving less than its ordinary quota of water, there was here more or less channel deterioration. The high waters of the summer of 1907 did not, therefore, find as free an outfall to the Gulf as they would have found if there had been no such channel deterioration. This condition was foreseen by those who were in touch with the situation on the lower Colorado River, and speculation was rife as to whether the river would rise to unusual heights, and whether the dams across the two breaks and the newly constructed west side levee would successfully withstand the anticipated high-water stage. There seemed to be nothing to fear from an overtopping of the works. The levee crest and the tops of the dams are higher by several feet than the embankments on the Arizona side of the river. If the river had risen to a very high stage it would have found relief by sending its floods over the east side lands long before reaching the height of the west side levee. But the dams and the levee had not yet been subjected to the high-water condition, and there was some uncertainty relating to the possible depth of water that would be turned by the down-stream section of the levee, which swings several miles away from the river, following quite closely an insignificant channel on relatively high ground, which appears to be one of the feeders of Paredones River. Neither could it be foretold what the current inland along this section of the levee might be; nor whether there would be any deleterious seepage under the levee, when water stood at some depth on its outer slope.

The levee, which has a total length of about 14 miles, supports a railroad. It is covered, crest and slopes, with a thick blanket of gravel and short spurs of brush and gravel extending out from its water slope will offer some obstruction to parallel currents. The levee height is generally about 8 ft. It was carefully patrolled during the rising stage of the river in 1907, and men, materials and appliances were held in readiness for any emergency work. Every reasonable precaution was taken by Mr. H. T. Cory, the engineer who had charge of the construction of these works, to maintain them against any weakness that circumstances might develop.

But the discharge of Colorado River gradually increased during May and June, 1907, to a maximum in excess of the ordinary summer flood stage, without at any time rising above the general bank height near the Lower Mexican Heading. The bank was only overtopped in low places and the base of the levee was not wet throughout its entire length. There was no time during the entire high stage of the river in June and July, 1907, that any menace to any part of the defensive works along the river was apparent. This highly satisfactory condition is readily explained. The river, which in its original condition annually rose above bank heights at many points below the southern boundary line of California, submerging and watering the delta lands in Lower California, and promoting a rank growth of cottonwoods, willows, weeds and grass, had discharged its waters inland for a year. The natural summer irrigation of these lands did not take place in 1906. The lands in Lower California southward from the Lower Heading, dried out in large measure and many large areas were fire swept. Consequently, the overbank flow of the Colorado at points below the protected bank region in the spring of 1907 found ready and unusually free escape westward, dropping into the network of channels which feed the Pescadero River and other inundation channels that lead off toward the Volcano Lake and the Hardy Colorado. There was much such overbank flow at points 10 to 20 miles below the Lower Mexican Heading. The spill over the river bank, owing to the relatively unobstructed flow inland, increased in volume rapidly with increasing water elevation. Only a slight rise in the river was required to put all of the river's surplus water afield. Consequently the rising stage at points nearer to Yuma added to the river's effective fall and increased its current, thereby causing it to deepen channel rapidly. This deepening and consequent increase of channel capacity was very pronounced at Yuma, where the capacity was increased over 30% during the month of June.

Other causes contributed to the phenomenon, notably the fact that the river had cut through one or more necks of land below the Lower Mexican Heading, as at Nigger Bend, where it shortened its course some three miles, thereby adding about 3 ft. to the river's effective fall. Then, too, the river rose very gradually to its summer high stage, giving ample time for channel erosion before the crest of the flood passed Yuma.

The outpouring of an unusual volume of water into the Pescadero region was noted by the Indians, who reported more water in that part of the delta in 1907 than had ever before been known. It was apparent, too, in the rapid rise to a full stage of Volcano Lake, which during 1907, at variance with conditions in preceding years, had received little or no water from Paredones River.

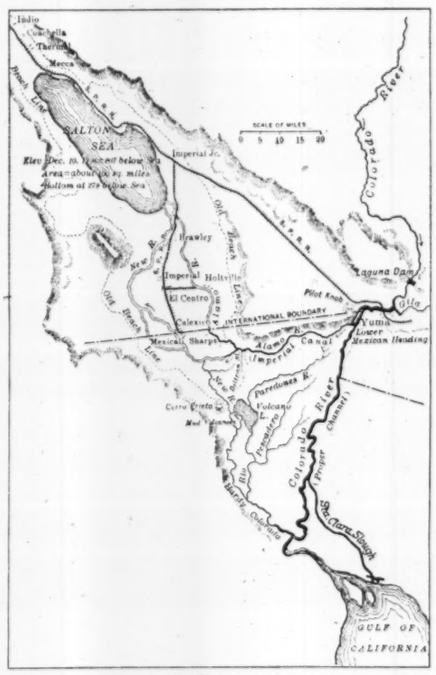
The unusual flood volumes of the Colorado River at last year's summer stage did not, however, sweep across country toward Volcano Lake and the Hardy Colorado without effecting some channel erosion on its way. The land from the river toward Volcano Lake falls away on a gradient of several feet per mile, whereas Colorado River has a fall of only about 1 ft. per mile. The water, therefore, wherever it could concentrate in a channel or other natural depression, had a swift current and rapidly cut into the friable soil. Among the channels reported to have been thus materially enlarged is a feeder of the Pescadero, the Abejas, the upper end of which is, however, still some six miles

*Consulting Engineer, 45 Broadway, New York City.

[†The break in the Colorado River and the methods employed in closing it have been described in detail in Engineering News, as follows: A general review of the subject, Feb. 22, 1906; letter of comment from Edwin Duryea, Jr., March 15, 1906; a discussion of the rate of filling of the Salton Sink by water from the Colorado River, May 10, 1906; history and description of the attempts to close the break up to the first successful closure, by H. T. Cory, Dec. 27, 1906; notes on the work of closing the second break, Jan. 31, and Feb. 21, 1907; levee construction, by H. T. Cory, July 11, 1907. A lengthy editorial discussion of the break and lessons to be drawn from it appeared in our issue of Feb. 21, 1907.—Ed.]

distant from the banks of the Colorado River. In case that this channel cuts back during future high waters to the Colorado and then becomes the river channel, there may be some modification of river gradients, though by no means to an extent comparable with those which would have resulted if the river had a year ago maintained a delivery of its waters into the Cahuilla Basin.

It is not probable, moreover, that the back cutting of this feeder of the Pescadero will be as rapid hereafter as it was last season, because the river banks have again been well watered and hereafter there probably will be much obstruction offered to a free inland flow of flood waters by rank vegetation. Such obstruction is likely to prove effective unless the choked condition of the river sections nearer the Gulf is beyond improvement by the natural scouring effect of the river. This will probably be made apparent during the spring freshets of the current year. The choking of the lower sections of the Colorado River is notable. The volume of flow at the high stage dwindles to a fraction of the discharge past Yuma; the surplus is forced



Sketch Map Lower Colorado River and Salton Basin.

to go over-bank. It was reported in the summer of 1907 that Santa Clara slough, an east side inundation channel, had become the main stream. This may have been the case, but it did not remain so. As the water fell to lower stages it was all in the proper channel of the river.

A change in the course of the river to the Pescadero and thence by way of Hardy's Colorado to the Gulf, which must be admitted to be a possibility, should not be regarded as a menace to the Imperial Valley and to the other improved sections in the Cahuilla Basin. The river, if it takes this course, will lie to the southward of the flat summit which separates the Gulf from the basin. The only point where this summit is penetrated is at Volcano Lake, whose waters brought in formerly in the main by Paredones River, now by the Pescadero, flow from the lake both to the south in the Hardy Colorado and to the north in New River. The flow to the north, which last year was a contribution of some moment to Salton Sea, can readily be stopped by a small dam and levee. These structures are so obviously necessary that they undoubtedly will be constructed, if they have not already been put in place.

If the Colorado River makes the change, which now appears as a possibility, there will without doubt be some lowering of the river bed above the point at which the break is made through the river bank. That this must occur is self-evident. The river would not turn from its present course if there were not a freer outfall along the new course. It will at once begin to adjust its gradients by cutting down elevations above the point where it leaves its old channel and by building up in the lower reaches. How much it will cut down cannot be foretold without more knowledge of the probable new alinement of the stream than is now available. It is not likely that it would be of such an amount as to interfere with water diversion into the Imperial Canal or with the works that are being constructed by the U. S. Reclamation Service above Yuma. A small amount of permanent channel deepening should be welcomed, because this more than anything else would aid in keeping the high stages of the future within banks and away from the protection works at the Lower Mexican Heading, where the occurrence of a breach would be more likely than anywhere else to permanently turn the river inland.

FORMULAS FOR THE DESIGN OF CABLEWAYS.

By EDWARD B. DURHAM,* E. M.

CABLEWAYS.—These are aerial transportation machines in which the mechanism hoists as well as transports a single load on a single span of cable. The load is often very large and does not pass the towers. The cable being fixed at both ends may be considered of constant length. (Several of these conditions do not apply to the Brothers cableway, made by the Balanced Cable Crane Co., New York City; this machine, therefore, is not included in this discussion.)

AERIAL TRAMWAYS.—These are aerial transportation machines in which the loads, often small and numerous, are hauled along a fixed track cable by a moving traction rope. The carriers may be arranged to pass the towers. The cables are tightened by means of weights, so that the tension is known. The tramway, in fact, utilizes the familiar principle of the street cable road, except that the carriers hang from the track cable, on which they run, instead of traveling on solid rails.

These detailed definitions of the two types of machine are intended to bring out those differences which affect the calculation of the cable curves, and which are often confused. Particular attention is directed to the fact that in the cableway the *length* of the cable is constant (neglecting variations of temperature and stretch), while with the tramway the *tension* in the cable is known, although not uniform.

Ordinarily in the statement of the formulas for cable curves, little is said about the derivation or application of the formulas. A brief study of their derivation, in the present article, will make the method of application more clear.

The problem usually presented to the designing engineer is to build a cableway to span a given area, and to handle a certain amount of material per hour.

A study of the topography and other conditions affecting the question of clearance, leads the engineer to decide on the sag that he can allow in the cable with the load at the center. A common practice is to use a deflection of $^1/_{20}$ to $^1/_{10}$ of the span, as giving a sag that is usually not objectionable, and one that does not cause an excessive stress in the cable. The fall block, skip and parts of the carriage below the cable will consume an additional 15 ft. of head room. If the span given is 1,000 ft., the deflection of the cable would be 50 ft. for a ratio of $^1/_{20}$ of span, to which the 15 ft. clearance for machinery must be added, making the towers 65 ft. or more in height, if the cableway is to be operated on level ground. Of course, if the cableway spans a ravine or quarry the towers may be lower, provided there are no obstructions near the ends of the span.

In determining the maximum load, knowing the hourly capacity desired, it is necessary to analyze the operation of the apparatus, and to determine the time used in each movement, in order to get the number of trips that can be made in an hour. The operations usually consist of hooking onto the load, hoisting the load vertically, hauling the load along the cable, lowering and dumping, rehoisting, running back to the loading point, lowering and unhooking. The hoisting and lowering may be done at a speed of 300 to 400 ft. per min., and the hauling along the cable may be at a speed of 600 to 800 ft. per min., the lower speeds being used for the smaller hoists and hauls.

It is assumed that such a calculation has been made, and that the load to be carried per trip has been determined therefrom. Then the engineer has given: (1) the span, (2) the net load, and (3) the deflection, the latter being tentatively chosen as some fraction of the span. To the net load is to be added the weight of the carriage and fittings, say 50% of the net load, to get the gross concentrated load on the cable.

The size of the cable and the tension under which it is to work are inter-related quantities, since the larger the cable the greater the tension it can sustain. A few trial solutions of Eq. (7) will determine the size that is best suited to the problem in hand. The method of using this formula will be shown after its derivation has been discussed.

The form of the unloaded cable is assumed to be a parabola. Its equation is derived with the aid of Fig. 1. Let:

S = horizontal span, in feet,
d = vertical deflection of the unloaded cable at the center of the span, in feet,
W = weight of the cable for the whole span, in pounds, and equal approximately to $w S$,
w = weight of cable per lineal foot, in pounds,
t = tension of the cable at the center, in pounds, equal to the horizontal component of the tension of the cable at any other point,
T = tension of the cable at either end of the span, in pounds, and,
θ = angle of inclination of a line tangent to the cable at the ends of the span.

From the properties of the parabola, the tangent to the curve at A or B cuts the middle

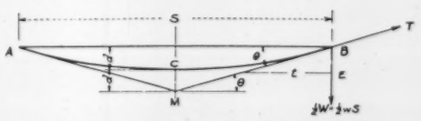


Fig. 1. The Curve of the Empty Cable.

vertical at a distance from the chord equal to twice the deflection d; therefore the slope of the tangents A M and B M is given by the equation,

$$\tan\theta = \frac{2d}{\frac{1}{2}S} = \frac{4d}{S} \quad \ldots\ldots(1)$$

At B, the pull or tension of the cable T can be resolved into horizontal and vertical forces B A and B E. But B A equals the horizontal tension in the cable at C, which is equal to t, and B E equals half the weight of the suspended cable $\frac{1}{2}W$, hence:

$$\tan\theta = \frac{\frac{1}{2}W}{t} = \frac{W}{2t} = \frac{wS}{2t} \quad \ldots\ldots(2)$$

Combining equations (1) and (2),

$$\frac{4d}{S} = \frac{wS}{2t}$$

$$\text{or } d = \frac{wS^2}{8t} \quad \ldots\ldots(3)$$

This equation applies to cable curves where the chord is horizontal, as in the figure; but it is applicable with small error to cases where the chord is slightly inclined. In all cases the deflection is laid off vertically. Happily most of the problems that arise have spans whose ends are at the same elevation, or nearly so, and the complications incurred in the calculation of spans with inclined chords will not be discussed in this paper.

When a weight is suspended from two points by two cords of equal length, a polygon of

*Chief Draftsman, The Trenton Iron Co., Trenton, N. J.

forces is obtained as shown in Fig. 2, the cords A C and C B being without weight. If

g = weight of the suspended load, in pounds.
ϕ = angle of inclination of the cords A C and C B,
d' = vertical distance of point of application of load below points of support,

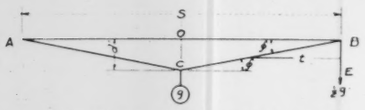


Fig. 2. Diagram of the Loaded Cable.

the pull of the cord C B at the point B may be resolved into a horizontal force A B = t and a vertical force B E = ½ g, giving the relation:

$$\tan \phi = \frac{\frac{1}{2} g}{t} = \frac{g}{2 t} \quad \ldots\ldots (4)$$

But in the triangle O C B

$$\tan \phi = \frac{O C}{O B} = \frac{d'}{\frac{1}{2} S} = \frac{2 d'}{S} \quad \ldots\ldots (5)$$

Combining (4) and (5),

$$\frac{g}{2 t} = \frac{2 d'}{S}$$

$$d' = \frac{S g}{4 t} \quad \ldots\ldots (6)$$

The total deflection caused by a concentrated load and by the weight of the cable supporting it, Fig. 3, is the sum of the deflections caused by their separate weights as given in Eq. (3) and (6). In this case, let D denote the vertical deflection at the center of the span due to both the cable and the concentrated load; then,

$$D = d + d' = \frac{w S^2}{8 t} + \frac{S g}{4 t}$$

or

$$D = (w S + 2 g) \frac{S}{8 t} \quad \ldots\ldots (7)$$

This equation enables the deflection to be determined for any one size of cable by substituting the value of t and w for that particular cable, together with the known values of S and g, and solving for D. The allowable tension t is usually taken as one-fourth the breaking strength of the

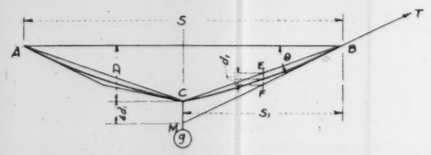


Fig. 3. Deflection of Cable Under Its Own Weight and a Concentrated Load at Center.

cable; w is the weight per linear foot of the same cable. Values of t and w for different sizes of cables can be substituted in succession until a cable is found that gives a satisfactory value of D, the total deflection, under the conditions governing the permissible sag in the particular case in hand, as already discussed.

The table below gives the properties of the different sizes of locked wire rope, which is the type of cable that practice has proven to be the best for the track cables of cableways, on account of its long life and the small wear it causes in the carriage wheels that run on it, as compared with ropes of ordinary construction. Fig. 4 shows this cable with its closely packed wires and smooth wearing surface that makes it resemble a solid round bar when in use, though it is flexible enough to be coiled for shipment, even in large sizes.

The last line of this table gives the sizes of the net loads that can be carried to advantage by the different sizes of cables, and is given only to indicate to the designer the approximate size needed for his conditions.

As an example of the method of using Eq. (7) and the table, take a span of 1,000 ft. and a net load of 4 tons; assume that the gross weight of carriage, fall block, skip, contents, and fittings will be 6 tons. The table gives a 1¾-in. diameter cable as suitable for 4 tons net load. Substituting its weight, w = 7.65 lbs. and using a tension of one-fourth the breaking strength,

$$t = \frac{129}{4} \text{ tons} = 64{,}500 \text{ lbs. in Eq. (7).}$$

$$D = (w S + 2 g) \frac{S}{8 t} =$$

$$(7{,}650 + 24{,}000) \frac{1{,}000}{516{,}000} = 61.3 \text{ ft.}$$

This corresponds to $D = \frac{S}{16}$ nearly. If a deflection of $\frac{S}{20}$ = 50 ft. is the maximum allowable,

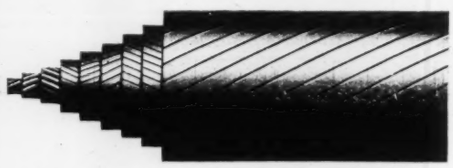


FIG. 4. LOCKED WIRE ROPE, AS USED FOR TRACK CABLES OF CABLEWAYS.

a larger cable must be used, say one 2 ins. in diameter. Trying this size, by substituting the values w = 10.0 and $t = \frac{170}{4}$ tons = 85,000 lbs., Eq. (7) becomes,

$$D = (w S + 2 g) \frac{S}{8 t} = (10{,}000 + 24{,}000) \frac{1{,}000}{680{,}000}$$

= 50 ft.

which meets the conditions.

The maximum tension T in the cable occurs at the towers and is represented by B M in Fig. 1 for an empty cable, and by the line B M in Fig. 3 for a loaded cable. Both these lines are tangent to the cable at the point B. The amount of this maximum tension is found graphically by laying off the horizontal tension t from B along the chord A B, projecting it vertically upon the line B M, and measuring the value of T on the inclined line between the vertical and the point B. Or, it can be found mathematically from the equation:

$$T = \frac{t}{\cos \theta} \quad \ldots\ldots (8)$$

The angle θ can be readily determined for the empty cable, Fig. 1, as its tangent is given by Eq. (1). But for a cable carrying a concentrated load, Fig. 3, it is necessary to take into account the sag of the cable for the short span from C to B, as well as the center deflection D.

Let S_1 and d_1 be the horizontal span and vertican deflection of the arc C B. Substitute these values for S and d in Eq. (3) and solve for d_1. The tangent B M to the curve at B passes through a point F, which is at a distance equal to $2 d_1$ below E, the middle point of the chord B C. This tangent, prolonged, cuts the vertical line through the center of the main span at M, distant $4 d_1$ from C; hence

$$\tan \theta = \frac{D + 4 d_1}{\frac{1}{2} S} = \frac{2 D + 8 d_1}{S} \quad \ldots\ldots (9)$$

The use of Eq. (3) to determine the deflection in spans with inclined chords is not exact, but is sufficiently so for the above purpose since the inclination of the chord C B is not great; and as d_1 is small, an error in it does not materially affect the slope of the tangent.

The ultimate or breaking strength of the cable, divided by T, gives the minimum factor of safety under which the cable is working when the load is in the most trying position, namely, at the center. For all other positions of the load on the span, the tension in the cable is less than found above. That this is true when ϕ is small can be readily seen by referring to Fig. 2. When the load moves to the left the sum of the two chords A C and B C remains constant; the point C describes an ellipse, and finally comes directly under A, at which time the tension in A C equals the weight of the load and C B equals zero, while with the weight at the center the tension in each of the chords is much greater than g. When ϕ becomes as large as 30° this ceases to be true, but that condition does not occur in cableway practice.

To determine the deflection of the cable for other positions of the load than at the center, it is necessary to resort to a different calculation than above, as the tension varies for the different positions of the load, and formulas containing that quantity as a constant cannot be used. But as stated in the beginning, the cable in a cableway is to be considered of constant length, as it is practically attached to both towers, and the variations of length due to temperature changes and stretch can be neglected as probably less than the inaccuracies in other features of the data obtainable. This condition of constant length of cable is used to determine the path of the point on the cable where the concentrated load is applied.

The length of the cable is obtained from Fig. 3, when the load is in the center, and is taken as equal to the sum of the two chords A C and C B.

Let l = length of cable in feet, then:

$$l = A C + C B = 2 \sqrt{\frac{S^2}{4} + D^2}$$

$$= \sqrt{S^2 + 4 D^2} \quad \ldots\ldots (10)$$

Here the fact that the arcs are longer than their chords has been neglected, and it will be neglected throughout this calculation as the difference between arc and chord, with these flat curves, is very small. The length of each arc can be found from Eq. (18), if wanted; however, in the case used as an example where the span was 1,000 ft. and the diameter of the cable was 2 ins., and its tension 85,000 lbs., the two arcs A C and C B are each only .07 ft. longer than their chords.

With the load at any point of the span, Fig. 5, let

m and n = length of the two chords of the cable A P and P B, whose sum equals l, all in feet.

z = horizontal distance of the load from one end in feet,

α = angle of inclination of the chord at the end from which z is measured.

D_1 = deflection at the load, in feet.

Then,

$$l = m + n \quad \ldots\ldots (11)$$

$$D_1 = z \tan \alpha$$

$$m = \frac{z}{\cos \alpha}$$

$$n = \sqrt{(S - z)^2 + D_1^2}$$

Substituting in (11),

$$l = \frac{z}{\cos \alpha} + \sqrt{(S - z)^2 + (z \tan \alpha)^2}$$

which on squaring reduces to

$$l^2 - \frac{2 l z}{\cos \alpha} + \frac{z^2}{\cos^2 \alpha} =$$

$$S^2 - 2 S z + z^2 + z^2 \tan^2 \alpha.$$

LOCKED WIRE ROPE—(Material, Cast-Steel).

Diameter of rope, inches	1	1⅛	1¼	1⅜	1½	1¾	2	2¼	2½
Weight per foot, lbs.	2.5	3.15	3.8	4.75	5.7	7.65	10.0	12.7	15.5
Breaking strength, tons	43	55	67	80	95	129	170	262	315
Net concentrated load, tons	½	1	1½	2	2½	3-4	5-6	7-8	9-10

or since

$$\frac{z^2}{\cos^2 \alpha} = z^2 \sec^2 \alpha = z^2 + z^2 \tan^2 \alpha,$$

$$l^2 - \frac{2\,l\,z}{\cos \alpha} = S^2 - 2\,S\,z \quad \ldots\ldots (12)$$

From this equation, the inclination of the chord can be obtained for any given position of the load, or, assuming α, the position z of the

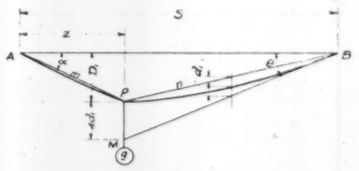


Fig. 5. Diagram of Deflection When Load is Not at Center.

load to give this inclination of the chord can be determined.

If z is assumed, Eq. (12) can be transformed thus:

$$\frac{2\,l\,z}{\cos \alpha} = l^2 - S^2 + 2\,S\,z \text{ and}$$

$$\text{or } \cos \alpha = \frac{2\,l\,z}{l^2 - S^2 + 2\,S\,z}$$

But Eq. (10) gives

$$l^2 - S^2 = 4\,D^2,$$

$$\text{Hence, } \cos \alpha = \frac{l\,z}{2\,D^2 + S\,z} \quad \ldots\ldots (13)$$

Note that D in Eq. (13) is the deflection obtained from Fig. 3, where the load is at the center of the span.

If x is assumed, Eq. (12) is to be solved for z thus:

$$z = \frac{1}{\frac{2}{\cos \alpha} - S} \frac{l^2 - S^2}{l} = \frac{1}{2\,l \sec \alpha - S} \frac{l^2 - S^2}{} \quad \ldots\ldots (14)$$

Eqs. (13) and (14) are especially useful in determining the position of the load as the carriage approaches the towers.

While α is the inclination of the chord on the short side it is also practically equal to the inclination of the cable at the near point of support. But if the inclination of the cable at the further tower, as B, is wanted, the deflection D_1 should be increased by 4 d_1, as was done in Eq. (9), in order to get the slope of the tangent B M.

$$\text{Then } \tan \theta = \frac{D_1 + 4\,d_1}{S - z} \quad \ldots\ldots (15)$$

The point of application of the load on the cable describes an ellipse, for the sum of the distances A P and P B is constant for all positions of the load. This fact cannot well be used for graphical solution of cableway problems, as the ellipse is so flat that the exact point of intersection of arcs struck from A and B is indefinite. However, this principle of the ellipse can be used to determine the path of the load by calculation.

A and B, the ends of the span, are the foci of the ellipse. Let the origin be taken at O, the center of the span, which is also the center of the major axis; O C, equal to the deflection D due to the cable and a concentrated load at the center of the span, as found by Eq. (7) is also the semi-minor axis b, while C B is equal to the semi-major axis a. The ordinates of any point P are denoted by x and y. The equation of the ellipse referred to the origin at the center is:

$$a^2\,y^2 + b^2\,x^2 = a^2\,b^2$$

and by transposition,

$$y^2 = \frac{b^2}{a^2}(a^2 - x^2)$$

But $b = D$, whose value was found by Eq. (7), hence,

$$y^2 = \frac{D^2}{a^2}(a^2 - x^2) \quad \ldots\ldots (16)$$

From Fig. 6 it is evident that,

$$a^2 = D^2 + \frac{S^2}{4} \quad \ldots\ldots (17)$$

Eq. (17) gives the value of a^2 for any particular case. This value substituted in (16) gives an equation in which only x and y are unknown. By assigning a series of values to x, the values of the corresponding ordinates y are easily obtained, and the path of the load determined by a series of points. As already pointed out, the effect of the sag on the length of the segments A C and C B is very small, and has therefore been neglected.

The effect of omitting the sag of the two segments of the cable from the calculations last given is an error on the safe side. As the load travels from the center toward either end, one chord increases in length and the other decreases, but the sag of the longer chord increases more rapidly than the sag of its mate decreases; the effect is to shorten the ordinate y a little, and so give a very little more clearance than calculated.

In erecting the cable it is desirable to know the necessary amount of sag to be given the empty cable in order to have the desired deflection when the load is applied. The length of the cable is the same in both cases, and from this length and the length of the span the deflection can be determined.

The length of the cable when loaded as in Fig. 3 is given by Eq. (10), as

$$l = \sqrt{S^2 + 4\,D^2}$$

The length of a cable when hanging in a curve due to its own weight is given by mathematicians as,

$$l = S + \frac{8\,d^2}{3\,S} \quad \ldots\ldots (18)$$

in which l is the length of the arc, and d and S are the deflection and span, respectively.

Transposing, Eq. (18) gives:

$$d^2 = \frac{3}{8}\,S\,(l - S) \quad \ldots\ldots (19)$$

If Eq. (10) is now solved for l and this value substituted in (19), the required center deflection d for the empty cable is obtained.

If this distance, d, is measured down from the saddle at each end of the span, and a mark placed on each tower, the cable can be tightened up until

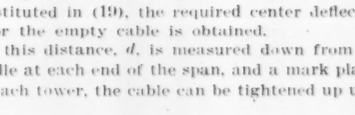


Fig. 6. The Elliptical Path of the Load.

the lowest part of its curve is in line with these two marks, as determined by an observer sighting across them.

As an example to illustrate this calculation, let $S = 1{,}000$ ft., and $D = 50$ ft., then from Eq. (10),

$$l = \sqrt{1{,}000^2 + 4 \times 50^2} = 1{,}004.99 \text{ ft.},$$

which substituted in (19) gives

$$d^2 = \frac{3}{8} \times 1{,}000 \times 4.99,$$

$$d = 43.26 \text{ ft.},$$

which is the distance of the lowest part of the curve of the empty cable below a line through the saddles.

If Eq. (3) is transposed to the form $t = \frac{w\,s^2}{8\,d}$ and the value of the t substituted in the expression $T = \frac{t}{\cos \theta}$ (See Fig. 1), the result is the value of the tension that must be applied to the end of the cable to draw it to its final position while empty, and indicates the strength of the tackle required.

AIR-RESISTANCE EXPERIMENTS BY A NOVEL METHOD.

Some experiments on air resistance, conducted during the past two or three years by Mr. G. Eiffel, and described by him recently before the Société des Ingénieurs Civils de France, employ a very novel method. The experiments were made by attaching the test surfaces to the bottom of a heavy weight, which contained also the measuring and recording apparatus, and dropping this from the second story of the Eiffel Tower, a height of 380 ft. In order to guide and arrest the apparatus, it was arranged to slide freely down along a smooth vertical rope, and the lower end of this rope, tapering to a larger diameter from a height of some 65 ft. above the ground, engaged a set of spring-seated brake jaws on the apparatus, and thus brought the falling mass to rest without shock.

The means for measuring the air resistance, time and distance of fall, were as follows: The test surface, pressed upward by the resistance of the air, bore against calibrated springs, whose compression gave a measure of the resistance. In compressing the springs it moved a writing point along a vertical recording cylinder covered with smoked paper. This cylinder was rotated by a friction wheel or roller pressed against the rope, so that the amount of rotation, or the abscissas of the diagram, gave a measure of the distance through which the apparatus had fallen at any instant. The writing lever formed part of a tuning fork of 100 vibrations per sec., set in vibration before the apparatus was dropped. This made the pen trace a wavy line, whereby the record embodied an accurate time scale. Time, distance and pressure were therefore obtained directly from the one line, and the velocity at any instant could be easily computed.

With this apparatus, various test surfaces, square, round and rectangular, of 1-16 to 1 sq. m. area (0.67 to 10.8 sq. ft.), were tested. Reducing the results to 760 mm. barometer and 59° F., Mr. Eiffel found that the well-known formula $p = KV^2$ held very closely. It seems that the exponent of V increases with V, having the value 2 in the neighborhood of velocities of 100 to 110 ft. per sec.; but the variation is small, and for practical purposes is negligible. The coefficient K varies slightly with the area of the test surface and its shape. The tests showed values of 0.07 to 0.08 (for velocity in meters per second, and pressure in kilograms per square meter), which correspond to the figures 0.0028 and 0.0033 where V is expressed in miles per hour, and p in pounds per square foot. The higher value seems to be a maximum reached only with rather large surfaces. [The coefficient 0.004 is widely used in America for transforming anemometer velocities into wind pressure.]

The apparatus used had a weight of about 250 lbs., and it seems that velocities up to 85 miles per hour were attained.

Experiments were also made on perforated surfaces, on superimposed surfaces, on dihedral surfaces, and on conical and spherical surfaces, but these do not appear to have been carried to a conclusion.

The preceding is taken from a brief report in the Mémoires of the French society, after a communication by Mr. Eiffel.

A MUNICIPAL GYMNASIUM at Brookline, Mass., was put in operation on Jan. 20, 1908. Since that date the weekly attendance has run up to 1,839. The gymnasium is under the charge of a physical director, who has organized a number of classes to meet local needs. Children as young as five years make use of the gymnasium. The use of the gymnasium is free to all except non-residents, the only expense to residents being that of providing uniform gymnasium suits. The gymnasium work done under the direction of the public schools will be carried on here. Years ago the town of Brookline opened municipal baths, which have been very successful. The public baths include swimming pools where instruction is given to pupils of the public schools and to others who wish to learn to swim. The gymnasium and the public baths are in general charge of a committee. Mr. J. Leonard Mason is physical director of the gymnasium and Mr. George S. Rich is superintendent. There is also an assistant superintendent and there are two gymnasium instructors.

NOTES ON THE DESIGN AND PERFORMANCE OF LOCOMOTIVE COALING AND ASH-HANDLING PLANTS.

By WILBUR G. HUDSON,* M. Am. Soc. M. E.

A recent report of the Committee on Buildings of the American Railway Engineering and Maintenance of Way Association (Bulletin 83, Jan. 1907) gives some very interesting figures in connection with its investigations upon the costs of operation of locomotive coaling plants of the various trestle and mechanical types. As the committee points out, because of the lack of uniformity of the conditions and the comparatively short period of time covered by much of the data, the figures are not to be taken for close comparison, but rather as indicating generally variations of costs with conditions. For ready reference the writer has summarized the results in Table 1.

In the East the high trestle with or without a power operated incline and the mechanically operated stations either with belt conveyor or link-belt machinery, are most frequently met. For several years the writer has been interested in the performance of these types, and while it has been practically impossible to get exact figures, the results of investigations have indicated that in the long run the operating costs for the two types of mechanical plants will be considerable better than for the trestle.

The latter because of the long approach often costs two or three times as much as a mechanical plant adapted to the same traffic. As regards maintenance, the exposed heavy timbers of the trestles will after eight or ten years' service call for repairs that are more expensive than the repairs to a sheathed pocket and its machinery if properly attended. Comparing concrete or steel structures, the interest on the greatly increased investment for a trestle and approach will outweigh the maintenance charge against the machinery of the lower priced mechanical plant; the repairs to the structure proper in either case being very small. The location selected may permit the installation of a trestle without requiring the expensive approach, in fact some sites are thus particularly well adapted. Fig. 1, showing the Pennsylvania R. R. trestle at Morrisville, Pa., is such a case, where, owing to the difference of level of the roadbeds near a junction, an approach is very

FIG. 1. CONCRETE AND STEEL LOCOMOTIVE COALING TRESTLE ON PENNSYLVANIA R. R. NEAR MORRISVILLE, PA.

neatly provided for by a spur from the higher main track. The trestle is very substantially constructed of steel with reinforced concrete sides and lining. There are 14 coaling chutes and one sand chute on each side. It is 200 ft. long, 14 ft. wide, and 19 ft. high above the foundations, which are 12 ft. 6 ins. above the base of the rail. Ashes are handled separately by being dumped on a concrete shelf in the familiar way.

In yards where all tracks are at nearly the same elevation a trestle approach takes up considerable space; and, if this yard space is available, it would seem better to have a light incline adapted merely to the weight of a belt conveyor, with cars discharging at ground level, than to run the cars themselves up over the bins, requiring a heavier construction throughout and a greater attendant risk to cars, men and locomotives. Where an essential condition is compactness the design providing for a vertical elevator receiving coal from a track hopper either adjacent to or beneath the pocket is easily the best.

Locomotive coaling stations of either type if constructed of wood are subject to unusual fire risk. Firemen are careless in cleaning fires in the neighborhood of the structure, and the dried timbers with deposits of pulverized coal, assure a furious blaze once a fire obtains a foothold. Current requests for estimates by the eastern railroads usually contemplate mechanical coaling stations of steel or reinforced concrete or concrete bins with steel supporting framework. If all-steel construction is preferred, the designer should see that corrosion will be prevented as far as possible. In many designs the locomotive stack is blowing gas directly upon the structure while the tender is being served producing rapid disintegration of the exposed members. Reinforced concrete seems to be preferable to either steel or steel and concrete, if the floor spans are not excessive, both as regards permanence and cost. On a recent proposal for an electrically operated coal and ash station with single coaling track and separate dumping track and designed for a bin capacity of 200 tons of coal and 50 tons of ashes, the prices for the complete plant were:

All steel construction	$12,000
All concrete construction	$11,200
All wood construction	9,000

Table I. gives also figures relating to three coaling stations of the locomotive crane type, covering a period of two years operation. These figures are very good, particularly as the cranes handle ashes in the intervals of coaling. A further recent development of this type which promises excellent results, is the long-boom crane with a working radius of 60 to 80 ft. The supporting track is therefore in a circular path of corresponding radius, about the dumping pit as a center thus providing a considerable ground storage. The crane can either load directly into the tenders, or better, be tributary to an elevated bin of 100 tons or more capacity, leaving the crane free for stocking out coal or handling ashes independently of the movement of locomotives.

FIG. 2. 800-TON BELT-CONVEYOR COALING STATION OF THE CENTRAL R. R. OF NEW JERSEY AT ELIZABETHPORT, N. J.

The committee before mentioned summarizes its investigations of the crane type of plant thus:

> At terminals where the demands are not too great, coaling can be done by means of a locomotive crane handling the coal direct from flat bottom cars to a locomotive. This crane can also help switch coal cars, if necessary, and can handle cinders and sand. To allow the use of drop bottom cars, a pit can be constructed from which the crane can handle the coal. To avoid delay to locomotives, a trestle can be constructed on which the crane can work, so that it can load direct into bins, in which a fair amount of storage room can be provided. The bins are not protected from the weather, and the coal and the gates are liable to be frozen up.
>
> With the necessary tracks, the pit and the hoppers, it will be found that this sort of a plant has a considerable first cost. Its cost of operation depends upon the work which can be provided for the crane at spare times. Its value is great in emergency situations and at points where, because of impending changes, the construction of a permanent plant is unwise. With a large terminal, where a conveyor plant is used, a locomotive crane would be very valuable to handle cinders and sand and also coal during a possible breakdown of the conveyor. The practical limit of a locomotive crane is said to be about 70 engines a day. The fact that it can unload direct from flat-bottom cars is much in its favor.

Exposed storage of anthracite has little effect on the coal. Some grades of bituminous coal suffer in heating value when stored in the open, while on the other hand this coal when stored in enclosed bins is subject to the risk of spontaneous combustion. Ordinarily coal will not remain in storage long enough to be seriously affected by exposure. There is, moreover, the element of expense, a structure suitable for the protection of several thousands tons of coal for locomotive service is very costly.

The locomotive crane is a heavily built machine not liable to disaster from foreign material in the coal. It does, however, call for a skilled attendant and to this extent may be out of business when most needed.

Coaling stations with conveyors most frequently employ belt conveyors, or steel elevators and flight conveyors in combination, each having its advantages over the other. When there is sufficient room available for the belt conveyor incline, this conveyor will give enormous carrying capacity, handling the coal smoothly and silently. It is absolutely essential that the belt be first class, with pure rubber armor on the carrying side and an effective bond between the rubber and the fabric constituting the body of the belt. The resistance of a good belt to the cutting tendency of abrasive material is remarkable as attested by the condition of belts in active operation five years or more. The belt should be protected from the weather. The manufacturers of belt conveyors list several grades of belting and for this heavy work the

*Vice-President, Guarantee Construction Co., 90 West St., New York.

TABLE I.—OPERATING COSTS OF LOCOMOTIVE COALING PLANTS.

(From Data Collected by The Committee on Buildings, American Railway Engineering and Maintenance of Way Association.)

	Trestles with elevated bins; small dump cars unloaded by shoveling. Williams White type.			High trestles with self clearing cars delivering directly into storage bins.				High trestles with power-operated incline.			Locomotive Crane.	Mechanical plant with elevating and conveying machinery.			Mechanical plant with inclined belt conveyor.		
Months covered by data...	9	..	†	10	1	1	9	3	..	1	24	6	1	..	10	12	3
No. of stations averaged..	4	5	1	6	2	17	1	1	5	55	3	1	3	4	4	1	1
Tons handled per day.....	235	133	13	305	370	440	67	264	166	82	195	165	147	345	280	127	218
Int. and depreciation, cts..	0.8	*1.0	1.7	0.5	*1.2	*0.8	2.3	1.7	2.7	2.7	1.5	*3.7	2.5	1.8	1.7	3.2	3.3
Operation, cents.....	10.3	11.3	20.6	3.1	6.1	3.6	2.8	3.5	5.1	7.0	3.9	2.7	3.7	2.4	2.7	4.3	3.1
Maintenance, cents	0.5	*0.5	2.2	0.5	*0.6	*0.4	0.1	*0.8	*1.3	0.9	0.5	*1.0	*1.0	0.5	0.5	0.6	0.5
Total operating costs per ton	11.6	12.8	24.5	4.1	7.9	4.8	5.2	6.0	9.1	10.6	5.9	7.4	7.2	4.7	4.9	8.1	6.9

*Estimated.
†Buckets and jib crane.
For interest and depreciation 10% of the original cost of the plant was used regardless of the type.

highest priced grade will be found the cheapest in the end. There should be two or more track hoppers for receiving coal, so that cars may be unloaded rapidly and without the delay otherwise unavoidable in cleaning out practically emptied cars.

When the plant is an important one a spare belt should be kept on hand for emergency. The incline should not exceed 20%. Fig. 2 shows a belt-conveyor coaling plant erected a few years ago by the Robins Conveying Belt Co. at the Elizabethport yards of the Central R. R. of New Jersey. The elevated pockets provide a storage for 800 tons of coal and 100 tons of sand. Coal is delivered from hopper bottom cars to a track hopper, thence through a grizzly to a feeder conveyor which distributes it to the main belt conveyor 240 ft. long rising at an angle of 18° to the top of the pocket and then continuing horizontally over the bins. An automatic self-reversing tripper distributes the coal into the storage. The conveyor has a capacity of over 150 tons per hr. and will easily unload a 30-ton car in ten minutes. Fig. 3 shows the general design, although as finally constructed the details vary from this somewhat. This plant, while not embodying the improvements of latest design, is a good example of an efficient arrangement standing up well under hard usage. Where large coal handling capacity is desired a plant of this type cannot be excelled.

When compactness is essential this condition is best met by a plant with a rigid steel-bucket elevator discharging into a conveyor above for distribution to the bins. The track hoppers, of which there should be two at least, should be equipped with feeders, preferably a slow moving apron conveyor, to prevent over-loading when the car is dumped. The elevator should be very ruggedly constructed, with heavy steel strap chains, bushed joints, with rollers for easy action at the sprockets and to reduce frictional resistance along the horizontal runs. The buckets should be of ample size to give the required capacity at slow speed, not over 100 ft. per min. Their attachment to the chains must be strong to prevent tearing loose under the shocks they are subjected to. These remarks apply as well to the distributing conveyor. All driving machinery, chains and flights must have a large margin of safety and be built for rough usage.

On very important plants the conveying machinery may with advantage be in duplicate, so that no ordinary breakdown can put the plant completely out of service. The motor or engine should be of ample size to start up the elevator and conveyor when fully loaded; and be geared to the driving machinery through some form of slip sprocket or safety pin, for release in case of jamming or overloading.

A point too often overlooked is the design of the coaling chutes. The old-fashioned plate cut-off gate is a nuisance, for control of the flow of coal with it is often impossible. Some form of undercut gate which cannot be blocked by the flow is essential. The chutes should be hinged and over counter weighted, so they must be pulled down to the coaling position and will swing up out of the way as soon as the flow of coal ceases; this removes any danger of having them ripped off by passing locomotives.

The floors of the bins should be inclined toward the coaling chutes at an angle of not less than 40°. If of wood, they may advantageously be sheathed with steel. When the floors have insufficient slope there is an accumulation of dead coal which does not flow to the chutes and which in time is liable to spontaneous combustion.

The proper storage capacity for the pocket depends on several considerations, but is usually fixed by the amount of money the company's engineer is allowed to spend for the plant. There should be at least a capacity sufficient for a 24-hr. run to avoid night work. The question of how coal will ordinarily be received should enter. To the railroad, the chief concern is to release cars promptly and as the conveying machinery will ordinarily have a capacity of 80 to 100 tons per hour, a 10-hr. run will release 20 to 30 cars if the pocket capacity permits. Large storage capacity increases interest charges but decreases operating cost, and liability to accidental interruption of service.

OPERATING COSTS.—In Table I., the costs of operating conveyor plants varied from 4.7 to 8.1 cts. (total cost of handling coal per ton). These costs will usually be lower as the tonnage handled is greater. Some figures the writer has at hand may be of interest as supplementing Table I.

The average labor costs from 12 stations of a railway in the Middle West is 1.4 cts. per ton. A typical record of one pocket near Pittsburg for one month is given in Table II.

Detailed records of the cost of operating eight coaling stations and trestles along the line of a large eastern railroad for one year were kept carefully and give an interesting record. Table III. shows the type of plant, the number of tons handled during the year, repair and operating costs and switching charges, all in total and per ton.

This is an interesting table and worthy of considerable study. The two-belt conveyor installations noted were at a disadvantage in handling material at nowhere near the full capacity of the belts, and in each case a new belt was charged up against the station during the year covered by the data. Wear on conveying belts is due principally to the bending of the belt back and forth and the cost of repairs per ton handled by a belt conveyor will be considerably lower where it can be operated at maximum loads. The figures for trestles are misleading, because no labor or material for repairs were charged against them for the year covered by the record. These charges are small for the first ten or twelve years of operation and considerably thereafter. The mechanically operated stations are unquestionably the most economical in the long run.

A good example of a long radius crane as arranged for combined coal storage and coaling station work is shown by Fig. 6. Table IV. is a report for three months' operation of this plant after one year's service.

ASH-HANDLING PLANTS.—In handling ashes we meet the difficulty that the water used in quenching becomes strongly corrosive, and ash-handling machinery is therefore considerably more expensive to maintain than that for handling coal. The service required will unavoidably be severe and the attention received will be slight owing to the unpleasant surroundings usually prevailing. The design must be strong and simple, with provision for easy renewals.

A number of ash-handling plants for locomotive service have been installed consisting of an elevated storage bin of concrete, encircled by a steel elevator whose lower run is arranged to receive ashes from hoppers beneath the tracks. Such conveyors are expensive, corrode rapidly and in this latitude and further north trouble is experienced in freezing weather. Very much worse, in the writer's opinion, is the practice of having a single conveyor for handling both coal and ashes, as has been done occasionally. This limits the life of the whole installation to the life of an ash-handling machine, whereas were it handling coal alone its deterioration and maintenance expense would be much reduced.

For both simplicity and economy the automatic-skip is probably the best all around machine for active service where the conditions permit its use. This consists of a bucket of

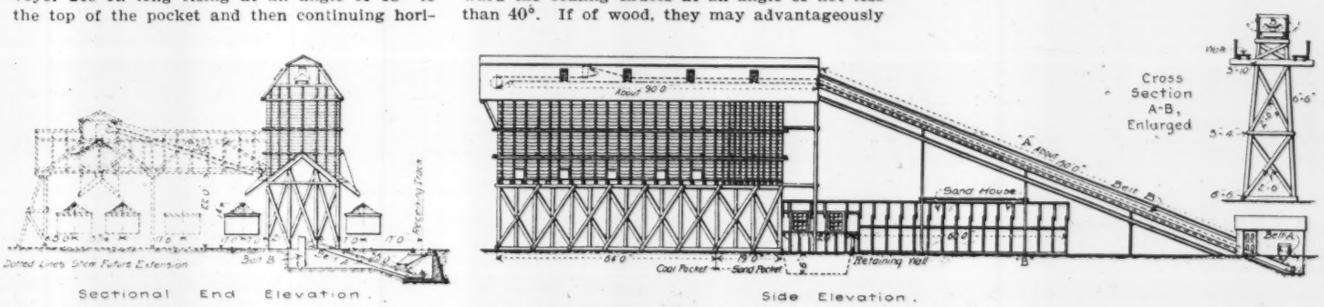


FIG. 3. ARRANGEMENT OF TRESTLE AND CONVEYORS; 800-TON COALING STATION, CENTRAL R. R. OF NEW JERSEY, ELIZABETHPORT, N. J.
(Built by The Robins Conveying Belt Co.)

TABLE II.—DATA ON ONE MONTH'S OPERATION OF A PITTSBURG LOCOMOTIVE COALING PLANT.

Number of engines supplied	766
Maximum time per engine	5 minutes
Minimum time	2 "
Average time	2.86 "
*Total cost	$92.00
Cost per engine	.12 cts.
Average tons per engine	4½
Cost of coaling per ton	2.67 cts.
Number of tons hoisted during month	3,606
Average time per carload	1 hr. 37 min.
Total cost for hoisting	$49.50
Cost per ton	1.37 cts.
*Cost of hoisting and coaling	4.04 cts.

*Including labor, repairs, power, and fuel, but not interest on the investment.

TABLE III.—OPERATING AND MAINTENANCE COSTS OF SEVERAL LOCOMOTIVE COALING STATIONS FOR ONE YEAR.

Type.	Tons Handled.	Repairs. Labor and material. Total.	Repairs. Labor and material. Per ton.	Switching charges. Total.	Switching charges. Per ton.	Labor dumping and coaling. Total.	Labor dumping and coaling. Per ton.	Fuel for operating machinery. Total.	Fuel for operating machinery. Per ton.	Total expense. Total.	Total expense. Per ton.
Bucket elevator	130,850	$275.48	0.21 cts.	$924.00	0.71 cts.	$4,394.44	3.36 cts.	$826.00	0.63 cts.	$6,419.92	4.91 cts.
Inclined belt conveyor	62,899	1,485.97	2.36	440.29	0.70	3,652.61	5.81	494.00	0.79	6,072.87	9.66
Bucket elevator	43,321	320.85	0.74	456.25	1.05	906.45	2.30	378.77	0.87	2,152.32	4.96
Bucket elevator	183,410	2,415.22	1.32	1,265.53	0.69	4,536.77	2.47	550.00	0.30	8,767.52	4.78
Inclined belt conveyor	47,109	1,456.71	3.09	234.47	0.71	2,473.70	5.25	316.00	0.67	4,580.88	9.72
*Trestle	110,138	†	†	813.60	0.74	4,631.78	4.21			5,445.38	4.95†
*Trestle	276,397	†	†	2,034.60	0.74	8,451.56	3.05			10,486.16	3.79†
*Trestle	61,570	†	†	800.41	1.30	2,056.85	3.34			2,857.26	4.64†

*Locomotive places cars.
†No record kept of repairs.

one or two cubic yards capacity, operated by an electric hoist which raises, dumps and returns the bucket automatically. A train of these buckets rests on tracks in the dump pit, their tops flush with the rails, and emptied as found convenient. The storage bin is of reinforced concrete with one or more discharge gates arranged so that ashes may be removed without interfering with the regular functions of the handling plant.

Fig. 4 is a good example of such a plant, erected in 1903 by the Link Belt Co. for the Pittsburg & Lake Erie R. R. at Hazelton, O. The

FIG. 4. ASH-HANDLING PLANT, WITH REINFORCED CONCRETE STORAGE BIN, PITTSBURG & LAKE ERIE R. R., HAZELTON, OHIO.

(Built by The Link Belt Co.)

bin has a storage capacity of 50 tons. There are two hoists spanning four tracks. Each ash pit is long enough to accommodate two engines, so eight cars be cleaned simultaneously. Ashes are emptied from the bin into cars on a track directly beneath.

Fig. 5 is a similar plant on the Pittsburg & Lake Erie R. R. at Groveton, Pa. The ash bin is of 30 tons capacity and is served by a single runway. One of the filled tubs is seen just being raised. It continues upward until it strikes the trolley, then trolley and tub move up the incline together, the bottom doors of the latter automatically opening when the bin is reached.

Beyond the ash plant is a typical 200-ton coaling station of the elevator-conveyor type with a timber structure arranged to coal locomotives on either of two tracks, while coal is delivered to the conveyor through a track hopper behind the pocket to the left. The conveying machinery is of standard type and will handle two cars per hr.

The advantage of the ash-handling plants illustrated by Figs. 4 and 5 are that the parts subject to corrosion, viz., the buckets and bin-discharge gates may be easily and cheaply renewed. Their operation is clean and rapid, and the several operations of dumping, hoisting and removing stored ashes are not interdependent.

Where the coal-handling plant is of fireproof construction, there is economy in space, time and cost in having the coaling and ash-handling stations adjacent and housed by a single structure.

With yards of moderate activity, an efficient and low-priced ash-handling plant may be installed consisting of a light steel bridge spanning two tracks and carrying a small trolley to which is secured a tackle for lifting tubs from the pit, and discharging them into a car on the adjacent track. A hydraulic lift or other simple device is emp'oyed. For small capacities this machine is excellent and quite generally used in the East. A bad feature is the necessity of al-

ways keeping a car at hand to act as a storage bin.

It is always hazardous to attempt to predict future practice, but it seems that development would proceed along the lines of concrete structures for the storage of both coal and ashes. The writer believes that machinery for coal handling will be in the form of heavy, slow-speed steel elevators and conveyors or inclined-belt conveyors, depending on the local conditions. For ashes the automatic-skip hoist appears best suited to survive. For combined service if not particularly active the long radius crane has some advantages.

The considerations of prime importance are not first cost, but reliability of operation, and low maintenance cost. The failure of one of the principal fueling stations is usually a very serious matter involving many times the difference in value between an obsolete type and an up-to-date install'ation. Almost invariably it may be said that, where a mechanical plant has been unsatisfactory in its operation, this has been directly due to inattention to the finer points of design and to an endeavor to cheapen the cost by installing conveying machinery too light for the work it had to do. Light machinery inevitably causes trouble. One important station is recalled where this skimping was obvious. The machinery had been in operation about 18 months. The light conveyor chains designed without rollers were badly worn from scraping along the guides, and were stretched out of pitch. The buckets were distorted and the driving machinery practically worn out. The repairs to such an installation more than balance the interest on the increased investment for a suitable design, while the annoyance and loss of time resulting from the frequent breakdowns are even more deplorable.

A DRAWBRIDGE WITH AN OPEN PIVOT PIER is to be built over the Bahr-el-Aama branch of the Nile at Cairo, Egypt, and this arrangement gives a greater area of waterway than a single solid pier. The circular girders carrying the turntable will be supported by five piers, four forming the corners of a square, and the fifth in the middle. The width over piers is 66 ft., and on each side is a clear navigable channel of 65 ft. The five piers are cylindrical, 8½ ft. diameter. The swing span will be 206 ft. long, with a 203-ft. shore span on each side. There will be two sidewalks and a roadway with a double-track street railway of meter gage. All the spans will be semi-through trusses. This bridge and with a longer one carrying the same road over the main channel of the Nile, were designed in the Public Works Department of the Egyptian Government. Several English and French firms were bidders, and the contract was awarded to the Compagnie de Fives-Lille, of France.

TABLE IV.—OPERATING COSTS OF AN 80-FT. RADIUS CRANE,—COAL STORAGE AND LOCOMOTIVE COALING SERVICE.

	December, 1907.		January, 1908.		February, 1908.	
Tons coal in storage first day of month	38,717		35,578		18,741	
Tons stored during month	725		000		000	
Tons delivered to engines	9,624*		9,718		8,615	
Tons reloaded for shipment	000		7,119		7,406	
Total tonnage handled in month	10,349		16,837		16,021	
Number hours crane operation	210		285		276	
Tons handled per hour operation	49.28		59.08		58.23	
Repairs to crane, Labor	$6.28		Labor $17.54			
Material	1.76		Material 1.50			
	$8.04		$19.04		0.00	
Crane operating charges, Labor	$100.25		Labor $102.16		Labor $88.75	
Fuel	44.25		Fuel 75.00		Fuel 40.00	
Supplies	5.64		Supplies 7.49		Supplies 4.28	
	$150.14		$184.65		$133.03	
Labor unloading cars into track pit	$80.10		0.00		0.00	
Labor coaling locomotives from storage bin	$84.18		$80.15		0.00	
Labor clearing coal from track before machine	0.00		0.00		$69.12	
Coal pocket repairs	0.00		$124.43		$5.59	
Switching services, Labor	$76.26		Labor $120.28		Labor $40.51	
Fuel	45.00		Fuel 77.50		Fuel 32.50	
Supplies	8.24		Supplies 6.03		Supplies 4.22	
	$129.50		$203.81		$77.23	
Total operation cost for month	$451.96		$612.08		$378.95	
Total cost per ton putting coal into storage	$.0529					
Total cost per ton delivering coal to engines	$.0429		$.0278		$.0228	
Total cost per ton reloading coal for shipment			$.0487		$.0248	
	451.96	612.08		378.95		
Total cost per ton coal handled by crane	= $.0437	= $.0363		= $.0236		
	10349	16837		16021		

*Of this amount 2,864 tons were taken from storage and 6,760 tons were loaded directly from cars to locomotive tenders.
†All coaling was by crane from storage piles direct to tenders.

CHEMICAL AND BACTERIAL EXAMINATIONS OF THE LONDON WATER SUPPLY.

The water supply of Greater London has been subjected to frequent chemical and bacterial tests for many years past. Since the acquisition by the Metropolitan Water Board of the works of the eight companies supplying London and vicinity, these examinations have been continued. At present Dr. A. C. Houston, well known to many of our readers for his work in connection with investigations of the Royal Commission on Sewage Disposal, is Director of Water Examinations (20 Nottingham Place, N. W., London, England). Dr. Houston's report for the year ending March 31, 1907, contains an interesting review of the tests made under his direction during the year, and also some suggestive notes on the relation of water storage to the character of the supply. A few typhoid figures are also given.

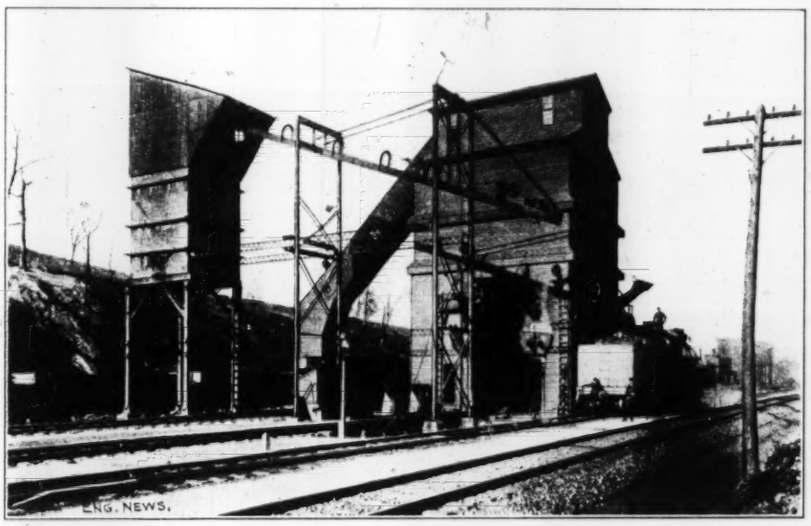


FIG. 5. COALING AND ASH-HANDLING PLANTS FOR THROUGH TRAIN SERVICE; PITTSBURG & LAKE ERIE R. R., GROVETON, PA.

During the year a total of 11,993 samples of water were collected and examined. The routine samples were taken at more than 150 different places. The average daily supply from the three main sources, it may be noted, were as follows: Thames, 154,560,000 U. S. gals.; Lee, 53,040,000; springs and wells, 61,680,000 U. S. gals. Various portions of the supply had different degrees of storage, and in this connection Dr. Houston makes the interesting remarks already noted. He calls attention to the desirability of drawing a distinction, from an epidemiological viewpoint, between *passive* storage, or the holding of water for emergencies, and *active* storage, or "habitually circulating raw river water through the storage reservoirs." As an example he states that the nominal number of days storage capacity for the Southwark and Vauxhall works during the year 1906 was 12.7 days, but actually the stored water was used only when the river was in flood. At other times, "raw unstored river water" in apparently good condition was turned in to the filter beds. A few paragraphs may be quoted from the report as follows:

> Undoubtedly from the epidemiological point of view, apart from questions of cost of pumping, the storage reservoirs should be so worked as to give each drop of river water abstracted for water-works purposes the maximum number of days detention in store. For example, given a single reservoir holding 65 days supply, it would be undesirable, on epidemiological grounds, to use raw river water for 300 days of the year, and during the remaining 65 days water which had been stored for periods varying from 300 to 365 days (passive storage).
>
> The proper procedure, apart from questions of quantity and quality, would be to maintain the water at top water level by pumping daily into the inlet end of the reservoir as much water as was being abstracted from the outlet end (active storage). Since, however, the quantity and quality of raw river water varies, a middle course of judicious selection of river water, according to the quantity available and its current quality, becomes necessary.
>
> The necessity of pumping greatly complicates the matter, because it is an economic loss to have a pumping plant sufficiently powerful to deal with a large volume of water in a short space of time if the plant has to lie idle during much longer periods.
>
> Existing regulations as to abstraction of raw water still further complicate the whole question.
>
> Apart from economic considerations, it may be said that every gallon of water pumped daily into store means a day's storage gained for each such gallon; every gallon drawn out of store daily without replacement of a similar amount means a day's storage lost for each such gallon; and although every day raw river water is utilized for water-works purposes means an extra day's storage gained for the total volume of water left in store this end can only be accomplished by incurring a certain element of immediate risk. "Safety" from the epidemiological point of view is not to be achieved by drawing on the storage reservoirs only when the river water is obviously impure, but by the habitual use of stored water; the drain on the reservoirs being made good by pumping river water into store as constantly as possible, and in amount inversely proportional to its current impurity.
>
> Conceptions as to the safety of utilizing an unstored water for filtration purposes must needs depend on the assumption that the filtration process is so perfect as to establish a sufficient margin of safety, provided the raw water contains less than the average amount of impurity. But in this connection it should be remembered that filtration is believed to be a relative, not an absolute, safeguard, and that even under the best conditions the rivers Thames and Lee admittedly receive the dry weather flow of the sewage, often imperfectly treated, of a large population. It is an under estimate that the sewage of over 1,000,000 and over 100,000 persons drains into the rivers Thames and Lee respectively above the Board's intakes.

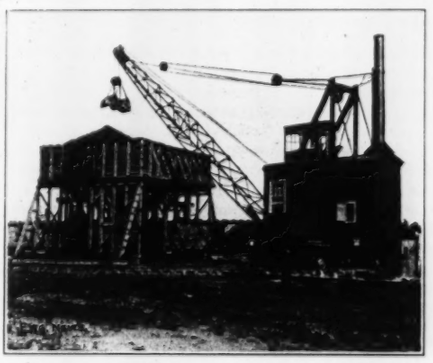


Fig. 6. 80-ft. Radius Crane on Circular Track.

(For coal storage and locomotive coaling service. Storage area is in the foreground. None was in storage at the time this photograph was taken. Cost of operating shown in Table IV.)

The average bacterial contents of raw and filtered water from various sources during the year are as follows:

Source.	Bacteria per c. c. Raw water: Average	Highest*	Lowest†	Filtered water.	Per cent. reduction.
Thames	1,680	5,246	277	22.5	98.9
Lee	7,253	28,986	471	27.	99.6
New River	1,099	3,795	149	10.1	99.0

*All the highest counts were in January.
†All the lowest counts were in April.

A total of 7,646 samples of filtered water were included in the above analyses. The gross average for all these samples was 19.9 bacteria per c. c., or only 10.8 if samples showing more than 100 colonies per c. c. be excluded.

Dr. Houston states that for water to be of satisfactory quality, hygienically considered, *less* than 50% of the samples of raw water should contain typical B. coli in 1 c. c., while of the filtered water *more* than 50% of the samples should contain *no* typical B. coli in 100 c. c. This, he admits, is a severe standard, but he considers it "not too high, having regard to the quality of the raw sources of supply." As an average for 12 months, all the London filtered waters, with one exception, reached the high standard last named, while of the total of 7,649 samples of filtered water, 75.4% attained this high standard.

As between typical and non-typical B. coli, the filtration processes, it appears, remove considerably more of the former than the latter.

On the subject of typhoid, we will only note that, according to the Registrar General's report for England and Wales, the total number of deaths from typhoid fever in London during 1906 was 260, giving a rate of only 6 per 100,000. The highest rates for any London boroughs were 11 for Bethnal Green and 14 for Finsbury.

In conclusion, Dr. Houston calls attention to the unsatisfactory condition of the raw London waters, particularly in winter; the importance of careful selection of raw water, which selection as a rule is only possible when ample storage is provided.

GAS METER TESTS to the number of 21,753 were made under the direction of the Public Service Commission for the Second District of New York during the six months ending Dec. 31, 1907. Of the meters tested, 799 were rejected: 396 because they were fast, 340 because they were slow, and 63 because they were unsound. Of the 20,954 meters sealed as coming within the error allowed by law, 6,008 were correct, 3,875 were fast and 11,071 were slow. Excluding "complaint meters," the average error of all the meters passed was 0.72%, and the average error of all incorrect meters 4.88%. The comments on the tests may be quoted from the report of the Commission as follows:

> For the purpose of making these tests, the Commission purchased a cubic foot measure standardized and sealed as correct by the Federal Bureau of Standards at Washington, D. C. The test is made by passing a cubic foot of air from the standard cubic foot through the prover and checking its registration upon the prover scale. During each test the room is saturated with moisture and care is observed to maintain at the same degree the temperature of the water in the prover and in the cubic foot and of the air in the room and in the bell of the meter prover. This operation is repeated for every cubic foot which the prover is marked to contain.
>
> The meter provers in use throughout the State by companies in testing the meters supplied to consumers have not heretofore been subject to official inspection properly required of standards of measurement.
>
> To date 73 provers have been submitted to the Commission for verification. Of these, 3 have been condemned as unfit for use; the scales of 20 have been ordered corrected and 50 have been approved in the condition in which they were found.

THE CALUMET-SAG CHANNEL, to divert the flow of the Calumet River from Lake Michigan into the Chicago Drainage Canal, is to be made the subject of a friendly suit to determine whether the work can be done notwithstanding the refusal of the Secretary of War to authorize it. The suit was entered by U. S. District Attorney Sims in the U. S. Circuit Court on March 23. On the same date, the Sanitary District of Chicago filed its answer to the complaint.

THE SCOPE OF THE PUBLIC SERVICE COMMISsions of New York City will be enlarged, provided a bill introduced in the Legislature becomes law, to include telegraph and telephone, ferry, stage, and gas and electric conduit companies. The two Commissions (one for Greater New York and the other for the other parts of the State) now have jurisdiction over steam and street railways and gas and electric lighting plants. Besides extending the jurisdiction of the Commissions as stated, the existing law is strengthened at some points.

THE TOWERS OF THE MANHATTAN BRIDGE OVER THE EAST RIVER AT NEW YORK CITY.

The construction of the third suspension bridge across the East River, between the Boroughs of Manhattan and Brooklyn, New York City, has progressed rapidly in the past year. The towers, fabricated by the Phoenix Iron Co., of Phoenixville, Pa., and erected by the Terry & Tench Co., of New York City, are near completion, as may be seen from Fig. 1, herewith, a recent photograph taken on the Brooklyn side.

A number of general and detail drawings of these towers were given in our issue of Aug. 3, 1905, pp. 107-117, being reproduced from the contract drawings prepared by the Department of Bridges of New York City. As may there be seen, each tower comprises four columns, one under each of the four cables of the bridge, the four columns being braced together transverse to the bridge, by crossed diagonals between the outer two on either side, and heavy portal construction between the two inner columns. Each column or leg has a narrow rectangular cross-section, with full plate-and-angle outer walls and numerous cross-walls, making a strong cellular box. The shorter dimension of the cross-section is constant at 5 ft. out to out; this is transverse to the bridge. The other dimension increases in a regular taper from the top to near the bottom, being 10 ft. at top and 20 ft. at the base of the taper, whence the lower section of the column flares out to a length of 33 ft. at the pedestal.

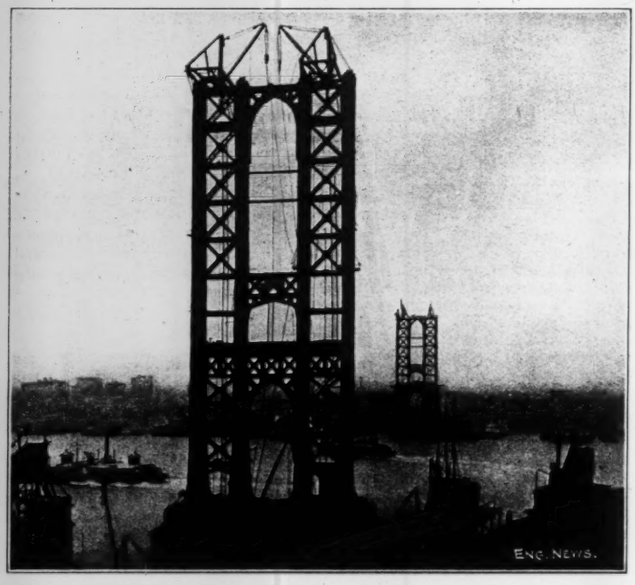


FIG. 1. TOWERS OF MANHATTAN BRIDGE, FROM BROOKLYN SIDE.

(Both towers as shown are erected up to a height of 264½ ft. above top of pier, that is, up to the bottom of the transverse bracing strut which connects the top of the two pairs of posts. The cap sections carrying the saddles are to be directly above this strut.)

The pedestal itself is 5 ft. 6 ins. high; it was originally intended to be of cast steel, made in 7 sections, and was so shown in a drawing in the article already referred to. For quicker delivery, however, it was actually made as a riveted steel built-up structure, following closely the outlines of the cast-steel design, but subdivided into only 6 sections. The bottom dimensions of the pedestal are: Length, 42 ft. 4 ins.; width, 21 ft. 10 ins., for a length of 14 ft. 8 ins. at middle; width, 14 ft. 4 ins. at ends. The bearing surface of the sole plate is 4 ins. less in each dimension, making the bearing area 695.5 sq. ft. The sole plate is 2 ins. thick. It rests on a 1-in. base plate set directly on the granite pier. The maximum intensity of pressure on the pier, at one edge of the base plate, is 64,000 lbs. per sq. ft., or 445 lbs. per sq. in.

The base plate is made in five strips, running parallel to the length of the pedestal. These strips cross the joints between the sections of the pedestal, and help to resist the spreading tendency of the pedestal. The excess of the spreading tendency over the friction developed between base plate and sole plate is taken up by 2½-in. bolts which tie together the several sections of the pedestal just above the sole plate. The maximum number of bolts is used between the end and second sections—18 bolts.

The cables of the Manhattan Bridge, unlike those of the Williamsburgh Bridge, but like those of the old Brooklyn Bridge, have loaded shore spans, i. e., the roadway in the shore spans is hung from the cables just as in the main span. In the Williamsburgh Bridge the shore spans of the cables carry only their own weight, and are therefore nearly straight. Both the Brooklyn Bridge and the Williamsburgh Bridge have their cable saddles mounted on rollers on the main towers, to allow for the lateral shifting of the cables due to the temperature changes or different load conditions on main span and shore span. In the Manhattan Bridge the saddles are fixed on the top of the towers and the top of the tower therefore must move with the saddle. In an earlier design for this bridge, made under the direction of Mr. G. Lindenthal, when Commissioner of Bridges, this motion was taken care of by pivoting the tower on a pin at the base. In the bridge as it is being built, however, the tower is fixed at the base, so that it must bend forward or backward as the position of the cable saddles shifts toward or from the river. These two peculiarities, fixed saddles and fixed tower base, control the design of the towers of the Manhattan Bridge.

The loads affecting the towers are: (1) Vertical load, from cables, considered as centrally applied; (2) moment of the vertical load, due to the deflection of the top of the tower; (3) moment of the lateral force developed by the bending resistance of the towers to the shifting of the saddles; (4) wind pressure on the towers; (5) vertical reaction of stiffening trusses (upward or downward) due to live load; (6) horizontal reaction of wind bracing of stiffening trusses. The weight of the suspended structure, i. e., cables, stiffening trusses, and finished floor, amounts roughly to 25,000 lbs. per lin. ft. The live load was assumed at two different values, 8,000 lbs. and 16,000 lbs. per lin. ft., either one being considered as a true moving load, i. e., acting either on the whole or on any part of the length. The value 8,000 lbs. is the "working" live load, or the equivalent uniform load of the greatest density of traffic which could occur while the traffic keeps moving in regular service. The bridge was designed for this load, using ordinary working stresses in the several parts of the structure; wind-pressure amounting to 2,000 lbs. per lin. ft. was combined with the "working" load. The load of 16,000 lbs. per foot of bridge represents a "congested" load, i. e., a condition of loading which might occur when trains, trolley cars, wagons, etc., are stalled, all of them being crowded in close contact. Such a condition would occur rarely, if indeed it will ever occur, in the life of the bridge. It was desired, however, that this emergency loading should not stress any part of the structure beyond the elastic limit, or even quite up to the elastic limit. The design based on the "working" load was therefore investigated for the "congested" load, and where the maximum stress found was somewhat below the elastic limit the adopted section was considered satisfactory. No wind-pressure was assumed acting under the "congested" load conditions. The "working" and "congested" loads are those recommended by a special commission called by Mayor Low in 1903 to report on the eye-bar chain designed for the Manhattan Bridge. (Eng. News, March 12, 1903, p. 243.)

The loads which came on the towers under these two conditions of loading are shown in the diagram, Fig. 2, for one column. The worst condition of loading for the whole tower is: Full live load on main span and farther shore span, and no live load or near shore span. When but half the width of the bridge is covered by live load the bridge floor is tilted slightly to the loaded side, thereby loading the cables unequally, which puts maximum load on the outer column of the tower. This condition was used to give the figures noted in Fig. 2.

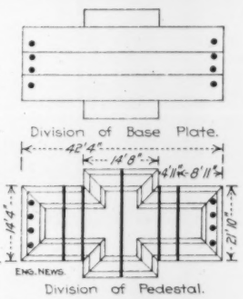


Fig. 2. Diagram Plan of Tower Column Pedestal.

Showing arrangement of sections of pedestal and sections of base plate.

The shift or bending of top of tower noted on Fig. 2 was calculated on the assumption that the tower offers no resistance to bending. That is, the shift is that amount of movement of the saddles which will bring the main and shore spans of cable into equilibrium under the given condition of partial loading. It appears that this shift of the saddles, by bending the towers, develops a resistance of several hundred thousand pounds, and this resistance will operate to reduce the shift slightly. The calculations therefore err on the safe side by a small amount.

The cross-section of the column has the following values:

	Area Sq. Ins.	Moment of Inertia Ft.⁴ × Ins.⁴
Top of Column	1,087	12,119
Near Roadway	1,877	52,280
At El. 47 (15 ft. above top of pier)	2,465	143,090
At base (incl. vertical diaphragms)	3,647	333,045

The maximum intensities of stress (dead plus live) in the column, under the condition of loading as described, are as follows:

Working Live Load:		
Direct Compression	— 7,800	lbs. per sq. in.
Bending	±11,500	
Wind, direct	± 1,100	
Wind, bending	± 1,600	
Total, Compression	22,000	
Tension	6,400	
Congested Live Load:		
Direct Compression	— 8,500	
Bending	±19,200	
Total, Compression	27,700	
Tension	10,700	

No wind is assumed for the congested loading because this loading is thought to be a sufficiently remote probability to make it unreasonable to provide for simultaneous wind action.

The erection of the towers was done by the use of an ingenious derrick platform adapted to travel vertically up the tower as the erection proceeded. This platform can be seen in the photographs, most clearly in Fig. 7. Two such platforms were used at each tower, one platform for either pair of columns. The platform projects outward from the face of the tower, on the shore side, and is supported by two bracket struts below. The tipping moment is resisted by two pairs of rollers or wheels, one at each column, which engage the vertical edges of the projecting middle panel of the column, the upper wheel being on the river side and the lower on the shore side. The vertical support is furnished by hooks engaging the projecting gusset plates of the bracing system.

A stiff-leg derrick is mounted at the middle of the inner side of the platform, being braced back to the outer corners of the platform. With this derrick the sections of the tower were lifted from

the top of the pier and set in place, the material having been transferred from scows to the top of the pier by floating derricks.

When a full section had been added to the height of the tower, blocks were fastened to the top and falls attached to the derrick platform, by which it then lifted itself to the next level.

For purposes of handling and erection each

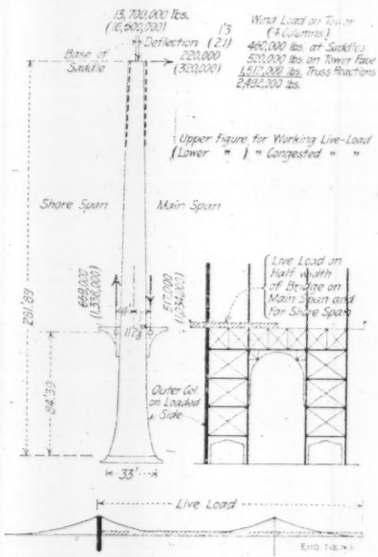

Base of Saddle
Deflection (21)
Wind Load on Tower (4 Columns)
Shore Span
Main Span
Live Load on Half Width of Bridge on Main Span and Far Shore Span
Outer Col. on Loaded Side
Live Load
ENG. NEWS

Fig. 3. Diagram of Maximum Loading and Deflection of Tower Column, Manhattan Bridge.

(For dead load combined with (1) working live-load of 8,000 lbs. per foot of bridge and (2) congested live-load of 16,000 lbs. per foot of bridge.

Live-load on main span and farther shore span, to give maximum bending moment on tower. Load on half width of bridge only, to give maximum load on outer cable of loaded side.)

column was divided by transverse and longitudinal field-splice joints into sections of convenient size. The transverse joints are 12 ft. to 27 ft. 6 ins. apart. Up to elevation 182.687, which is 145.727 ft. above top of pedestal, there are two longitudinal joints, dividing the column into three parts. The part above this has only one longitudinal joint. Fig. 5 shows the position of these joints in the cross-section, while Fig. 4 indicates the arrangement of field joints in the portion near the base of the column.

As may be seen from Fig. 4, the transverse joints are staggered, in the three-section part of the column. This made it necessary to provide for exact adjustment of lengths at the transverse joint where the three longitudinal sections change to two, in order to give a level bearing over the whole cross-section. The central section was therefore finished about ¼-in. shorter than the outer sections to leave room for shims. When the three sections had been set in place the difference of level of middle and outer sections was accurately measured and shim-plates, planed to this thickness, were set before the sections above were placed.

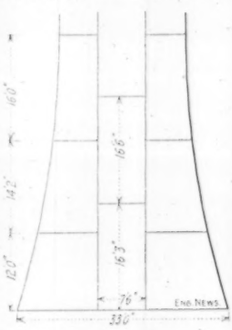


Fig. 4. Field Joints in Bottom Portion of Tower Column, Manhattan Bridge.

Riveting of the field splices was kept several sections back of the erection work. This gave opportunity for the transverse joints to come to full bearing. It was noticed repeatedly that a joint was apparently in imperfect contact when the section was first set up, but came to perfect bearing when two or three more sections had been set above it. The transverse joints, it should be noted, were faced on a planer and not, as commonly, on a rotary miller. The field rivets are 1-in., as are also the shop rivets in the main elements of the column.

The material of these towers is medium steel, specified to have an ultimate tensile strength of 60,000 to 68,000, and a minimum elastic limit of 33,000 lbs. per sq. in., with 44% minimum reduction of area. An abstract of some of the more important features of the specification was given in our issue of April 19, 1906, pp. 445-446.

The pedestal of each column weighs about 191 tons, and with its base-plate, etc., no less than 205 tons. Its largest section weighs 40 tons. The pedestals were set by floating derricks. The heaviest tower section is the middle section just below the roadway level, weighing 62 tons. The cap section, above the top of the work shown in the view, Fig. 1, weighs 52 tons, and the cable saddle 15 tons.

The general contract for the bridge was taken by the Ryan-Parker Construction Co., of New York City. The Phoenix Bridge Co., of Phoenixville, Pa., has the sub-contract for fabricating the steel work of the towers, and the Terry & Tench Co., of New York City, for the erection of the towers. The work is being done under the direction of the Department of Bridges, of New York City, Mr. J. W. Stevenson, Commissioner of Bridges, and Mr. C. M. Ingersoll, Chief Engineer. Mr. Alexander Johnson is Consulting Engineer, Mr. A. I. Perry, Engineer in charge of design, and Mr. D. E. Baxter, Engineer in charge of construction.

COMPENSATION OF GRADES ON CURVES.

The compensation of grades on curves (or the reduction of the rate of grade on curves) in order that the combined grade and curve resistance on the curve will not exceed the grade resistance on the tangents, is at present largely a matter of rule of thumb. It is true that the practice is based on tests and experiments, but these were made (by the late A. M. Wellington) some 30 years ago, and no later extended experiments have been made upon which to definitely base practice in regard to modern rolling stock equipment, trains and traffic. Present practice is largely a matter of imitation, each imitator introducing some modification to suit his own opinions or experience, so that present methods have really little relation to the old experiments upon which they are ostensibly based.

Some experiments have been made in Germany, and in our issue of June 19, 1902, we gave a diagram and brief particulars of experiments made with heavy ore trains on the narrow-gage lines of the South Australian Government Railways, a system which includes lines of 5 ft. 3 ins. and 3 ft. 6 ins. gage. Neither of these cases are of much value in dealing with the problem in this country, and in the issue above mentioned we quoted the conclusions presented in Wellington's "Economic Theory of Railway Location" as being the best exposition of the subject of grade compensation. A review of train-resistance experiments and investigations, together with a list of 60 train-resistance formulas, is given in the report of the Committee on Economics of Railway Location in the "Proceedings" of the American Railway Engineering and Maintenance of Way Association for 1907.

A communication recently received from a correspondent calls attention to this matter and to one particular rule relating to it. We quote the following extract:

> I would call attention to a rule commonly used by engineers which appears to me to be erroneous. This is the rule for compensation of grade for curvature, by which the rate of grade is reduced 0.03% per degree, or 0.04% for sharp curvature. There have, I believe, been no results of experiments in this matter published since those of Wellington's experiments in 1878. Conditions of track and rolling stock are now so changed that these old experiments should not now be used as a basis, even if they were satisfactory at the time. It does not seem to me that the experiments correctly represented practice, as the curve resistance was measured on cars dropped down a grade, while we want it in cars being pulled up a grade.

As far as the existing basis of rules for grade compensation is concerned, we have shown above that this appears to be of doubtful value for modern conditions. As to a rule requiring a greater rate of compensation for sharp curves, this was in use at one time, but we doubt if it is now being used to any extent, nor could it be justified. In Wellington's conclusions, above mentioned, it is stated that this rule (which he stated was then general practice) is based upon the erroneous assumption that curve resistance increases with the degree of curve. His own conclusion was as follows: "The rate of compensation should be uniform per degree for all degrees of curvature, or in no case made greater for the sharper curves. It may even be made less for curves of over 10°." The same principle is stated in Prof. W. L. Webb's "Railway Construction," to which we have referred below, and in Mr. Lavis book on "Railway Location Surveys and Estimates" a table of grade compensation is given in which the compensation decreases from 0.06% per degree for curves up to 2°, to 0.03% per degree for curves of 8° to 14°. From recent enquiry we find that the existing practice on some important railways is as follows:

Illinois Central Ry.—Compensate 0.04% per degree per station; increase this 0.1% at stopping places.

Louisville & Nashville Ry.—In the construction of new lines it has been the practice to compensate for curvature at the rate of 0.03% for each degree of curve. This has recently been found insufficient on lines having a great many curves; that is, where the curves are close together. It is probable that on future construction the compensation will be at the rate of 0.05%.

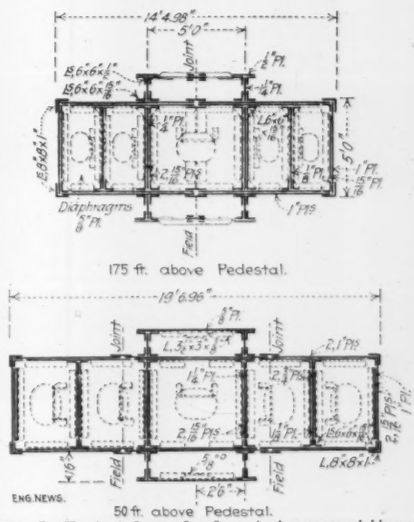


Fig. 5. Typical Cross-Sections in Lower and Upper Portions of Tower Column, Showing Location of Longitudinal Field Splice.

In compensating at stopping places, the practice is to reduce the grade 0.2% in addition to the compensation for curvature.

Chicago, Milwaukee & St. Paul Ry.—Compensation for curvature on maximum grades is generally at the rate of 0.035%. In some cases this is reduced to 0.03%. It is not the practice to compensate for curvature near stopping places, but if such stops are on maximum grades the grade is reduced 0.1% to 0.2%.

Philadelphia & Reading Ry.—Compensation is 0.04% per degree of curvature, and this applies also to stopping places.

Canadian Pacific Ry.—On ordinary work the compensation is 0.04% per degree of curvature, but in tunnels this is increased to 0.06%, on account of the probability of damp rails.

In his book on "Railway Construction," published in 1903, Prof. Walter L. Webb presented a series of rules for grade compensation, which were criticised by Mr. W. D. Taylor, now Chief Engineer of the Chicago & Alton Ry. (Eng. News, Dec. 10, 1903). These rules and criticisms we recently submitted to both Mr. Taylor and Mr. Webb, and the former states that he has not changed the opinions then expressed. We give below a compilation of the rules, with Mr. Taylor's criticisms and Mr. Webb's replies:

WEBB'S RULE NO. 1.—"On the upper side of a stopping place for the heaviest trains, compensate 0.10% per degree of curve."—This may be accepted as good practice.

WEBB'S RULE NO. 2.—"On the lower side of such a stopping place do not compensate at all."

Mr. Webb.—The illustration given by Mr. Taylor as an exception to the rule shows that the rule should perhaps have been stated more explicitly, although I relied on the previous discussion of the rules to make them perfectly plain. The very evident reason why compensation may be omitted on the lower side of a stopping place

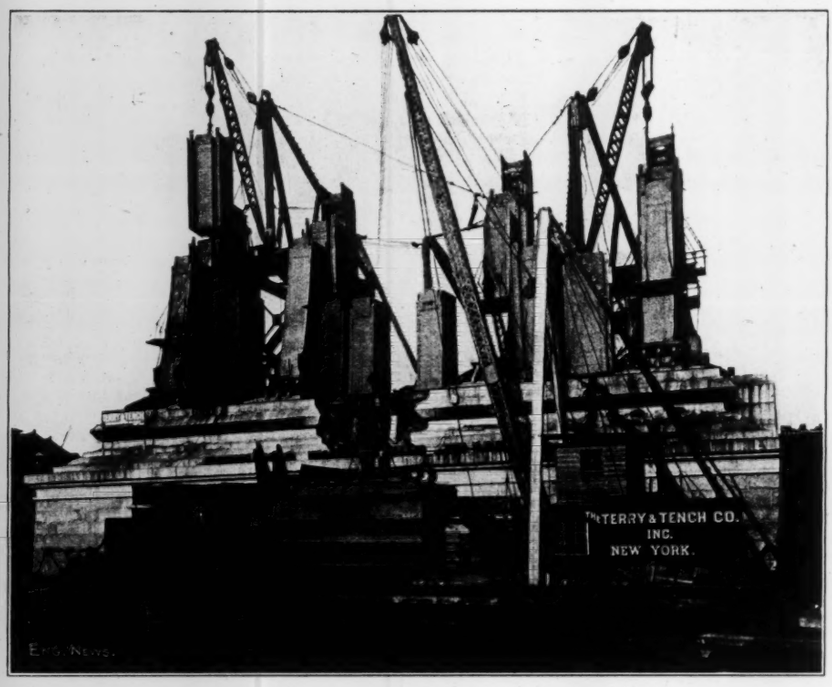


FIG. 6.

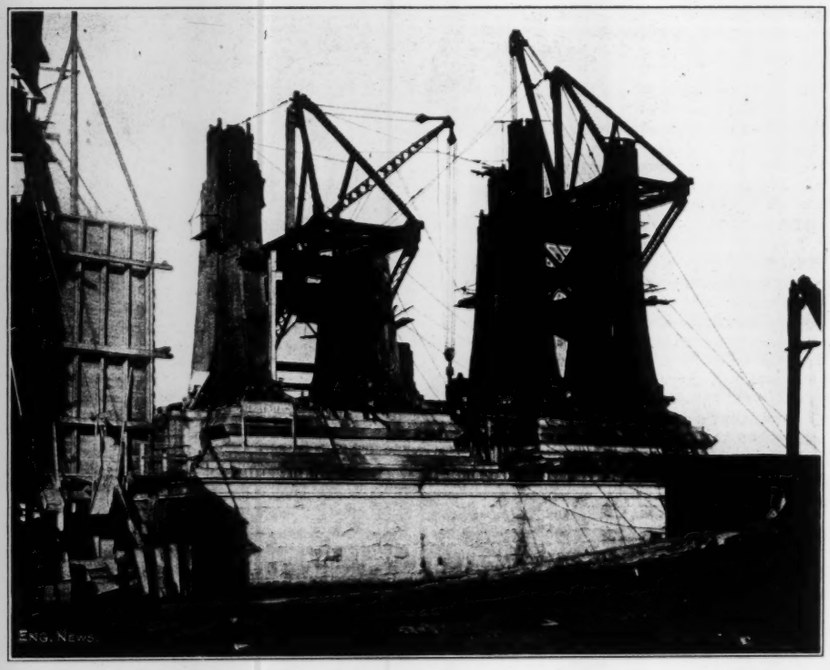


FIG. 7.

FIGS. 6 AND 7. ERECTION OF THE LOWER PORTIONS OF THE MANHATTAN BRIDGE TOWERS.

Mr. Taylor.—This cannot be accepted without modification. An 8-mile 1% grade to a summit, where there is a station at which all trains stop, has at 1,300 ft. below the summit 60° of 10° curve. If this curve had been left uncompensated, how many of the heavy coal trains loaded for the 1% grade could have got into the siding? for all trains is that the train is surrendering its kinetic energy at a rate which is so very much greater than the demand for energy on account of the resistance of the curve, that we may consider the curve resistance as merely reducing the work which would be required of the brakes. I can hardly consider the illustration given by Mr. Taylor as a legitimate exception, since a curve which is "1,300 ft. below the stopping place" is so far away from the stopping place that a heavy coal train running up a ruling grade would certainly not begin to apply brakes at that point. In my later book, "The Economics of Railway Construction," which is largely an expansion of the very condensed treatment of economics in "Railway Construction," I use the word "immediately" and make the statement "Curves which occur immediately below a known stopping place for all trains need not be compensated, for the extra resistance of the curve will reduce by that amount the work required from train brakes in stopping a train."

WEBB'S RULE NO. 3.—"Ordinarily compensate about 0.05% per degree of curve."

Mr. Taylor.—This will answer for a trunk line with light curves. In a case where long coal trains climb a long ascent the curves of 8° and under are compensated 0.035%, and the trains gain speed on the curves.

Mr. Webb.—It is appreciated that 0.05% is ordinarily an excess of compensation for trains at ordinary speed, but this figure was chosen on the general principle that it is preferable to have the compensation generous in case it does not involve any real sacrifice elsewhere. An accidental stoppage on such a curve would show that even 0.05% was not sufficient, and that it would hamper the train in starting.

WEBB'S RULE NO. 4.—"Reduce the rate to 0.04% or even 0.03% per degree of curve if the grade or tangents must be increased to reach the required summit."

Mr. Taylor.—This cannot be generally accepted. There is not much actual elevation lost in curve compensation, whether the rate is 0.03% or 0.05%. In one case a 1% grade 2½ miles long climbed an ascent in mountain country about as rough as most engineers have to deal with. Curves up to 10° were used. The rate of compensation was 0.04% for 4° and under, 0.035% for curves between 4° and 7°, and 0.03% for curves of from 7° to 10°. The elevation surrendered for compensation in the 2½ miles was 11.6 ft. The short summit cut was 67 ft. deep, and the long fill at the foot of the grade was 31 ft. high. The rate of compensation used was fixed in an effort to make the resistance up the grade uniform. How could this compensation be adjusted under rule No. 4 to materially alter the cost of the work without surrendering the object for which the compensation is introduced? However, rule No. 4 is more reasonable than No. 2 or No. 6.

Mr. Webb.—I fail to see the force of Mr. Taylor's criticism. He has previously admitted that 0.05% compensation is ordinarily excessive. The introduction of any compensation increases the grade on the tangents, and when the entire grade from base to summit is up to the limit of the ruling grade so that every possible foot of elevation must be saved, the engineer must very carefully balance his grades on tangents and curves so that the resistance is as nearly equal as possible, and so that on the one hand the grade on the tangent is not made needlessly excessive by using excessive compensation or on the other hand the curves become really the sticking points of the grade because the compensation is not sufficient.

WEBB'S RULE NO. 5.—"Reduce the rate somewhat for curvature above 8° or 10°."—This is universally accepted.

WEBB'S RULE NO. 6.—"Curves on minor grades need not be compensated."

Mr. Taylor.—There is always the possibility that with a growing traffic the maximum grades may be reduced or operated with a helper, and then the heaviest, or prevailing, minor grade becomes the ruling grade. There is a division on one of the Western roads which when constructed had in one direction one long 1.35% grade, uncompensated, with 4° curves and one 1.2% grade (nearly) with 5° curves. The remainder of the division was located on 1% grades over 4° curves uncompensated. The 1.2% grade has been reduced to 1% and the 1.35% is now operated with a helper. The ruling grade

is now very close to 1.2%, whereas if the prevailing minor grades had been compensated in the first place the number of loaded cars per train could have been from two to three greater than can now be pulled.

Mr. Webb.—The force of Mr. Taylor's criticism of this may be accepted on the consideration of possible future changes in the road. Of course the justification of the rule lies in the fact that when a curve on a minor grade is uncompensated it merely adds slightly to the virtual rate of grade, and since this addition will not ordinarily make a virtual ruling grade of the minor grade, unless the minor grade is already very near the limit, it has no effect on limiting train loads. Likewise, assuming that the base and summit of such a grade is not altered, the whole train must be raised through so many vertical feet of rise-and-fall whether the curves have been compensated or not. Therefore, as long as the grade remains a minor grade, it is practically immaterial whether its curves are compensated or not. As a matter of prudence, however, it would certainly be better to compensate the curves on all grades which are anywhere near the ruling grade, and even to discount the future by considering the possibility of future reductions in ruling grade, especially if this compensation may be accomplished without any material additional expense.

At the recent annual meeting of the American Railway Engineering and Maintenance of Way Association the Committee on Economics of Railway Location presented a report in which it stated that while some independent experimental work was referred to in replies to enquiries it had sent out, many of these replies simply stated the practice followed. There was considerable unanimity in the opinion that 0.04% was rather higher than necessary, 0.03% too low, and 0.035% about correct. The extreme variations were from 0.02% to 0.08%. There is a tendency to use a higher rate for the sharper tests made on the Pittsburg & Lake Erie Ry. in 1904 curves. It was shown that anti-friction devices under the center-plates and side-bearings have a very marked influence on the curve resistance and consequently upon the rate of compensation.

THE COMMUTATION OF PAYMENTS to the city of Philadelphia by the Philadelphia Rapid Transit Co., as provided for by a contract executed July 1, 1907, has been certified to by a board of arbitration. By the terms of the contract, the company will pay the city a lump sum per year in lieu of all street paving and snow removal work and all payments for car licenses. The amounts to be paid will be $500,000 a year for the first 10 years, $550,000 a year for the second 10 years, $600,000 a year for the third 10 years, $650,000 a year for the fourth 10 years, and $700,000 a year for the last 10 years of the contract. This will result in a total of $30,000,000 for the 50 years of the contract, or an average of $600,000 a year. It appears from information at hand that the payments stated relate only to streets now occupied by the company, and that additional compensation on the yardage basis is to be paid for streets occupied hereafter.

THE WRECK OF THE QUEBEC BRIDGE AND THE STRESSES IN THE BRIDGE.*

[Appendices 12 and 14 of the Quebec Bridge Commission's Report.]

The Quebec Bridge Commission, in its formal findings [Eng. News, March 12, 1908, p. 288] reported that the collapse of the bridge was caused by the failure of the bottom chord of the anchor-arm somewhere near the main pier. This failure was not due to external actions, but to the compressive stress in the chords, and, as the bridge was not yet completed, the stress was lower than it would have been in the finished bridge. That is, the chords failed at a load less than they were intended to carry *with safety* in regular service. This important conclusion, which, by the way, is identical with the tentative conclusions expressed by us in our issue of Sept. 5, 1907, immediately following the fall of the bridge, forms the basis for the entire discussion of column strength now going on in engineering circles.

The fuller statement and proof of this conclusion is contained in Appendix 12 of the Commission's report. It is followed in Appendix 14 by a presentation of the service stress-sheet, and this, together with a sheet showing the stresses existing at the time of the collapse, gives a clear picture of the stress conditions, a necessary adjunct of the conclusions as to the location and nature of the failure. We present here an abstract of these two Appendices, as full as limitations of space permit.

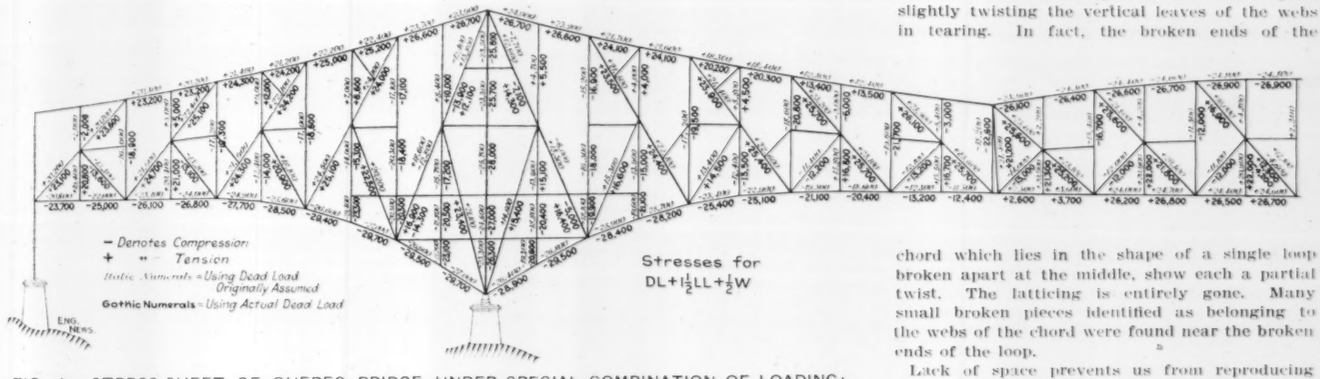


FIG. 1. STRESS-SHEET OF QUEBEC BRIDGE UNDER SPECIAL COMBINATION OF LOADING: DEAD-LOAD + 1½ LIVE-LOAD + ½ WIND.

(Stress given for tension members is on net section.)

The deductions as to the location of the initial failure are supported by several interesting drawings accompanying the Commission's report. One of these is a ground-plan of the wreck, showing the location of all the lower-chord members of the anchor-arm; it demonstrates most surprisingly that the lower chords fell exactly in the vertical planes of the trusses before failure, the only departures from this position being where a chord section was bent, so that the bent portion necessarily projects from the straight line, and where chords A 9 are found, these chords being bent and contorted laterally so that their larger part is considerably inside the line of the trusses.

Another drawing shows a plan of the position of floorbeams and stringers in the wreckage of the anchor-arm. This exhibits clearly that from the anchorage to panel point 7-8 the floor system fell practically as a unit, moving riverward as the anchor-arm swung forward on its anchorage leg, while the panels from the main pier back to panel-point 7-8 were shifted landward and crowded together, the stringers being forced out of their connection with the floorbeams. A specially remarkable fact shown by this plan is that the two westerly stringers in panel 9, immediately above chord A 9 L, are bent into a complete S shape; they are the only stringers so distorted. The four middle stringers of panel 8 moved north (riverward) some 50 ft., and are piled together with the corresponding stringers of panel 9.

A plan of the upper chords of the anchor-arm shows that both east and west top chords swung over toward the east. While this indicates a tipping toward the east, the exact alinement of the bottom chords and the floor-system shows that the tipping was an entirely subsidiary movement.

A large-scale ground-plan of the position and shape of chords A 9 L and A 9 R is also contained in the report. These are the chords which were bent into S-shape. The shape of A 9 L was represented by a sketch in our issue of Sept. 5, 1907. The opposite chord, A 9 R, has a more perplexing shape. Its south end is now north of its north end, but both ends still have their original direction; and the portion between forms a loop, and the middle of the loop is broken or torn apart. The shape is exactly that which would be produced if a fixed-end horizontal strut buckled in the middle and, with its ends moving straight toward each other and finally one of them passing the other directly over it, the vertex of the buckled portion were torn apart, slightly twisting the vertical leaves of the webs in tearing. In fact, the broken ends of the chord which lies in the shape of a single loop broken apart at the middle, show each a partial twist. The latticing is entirely gone. Many small broken pieces identified as belonging to the webs of the chord were found near the broken ends of the loop.

Lack of space prevents us from reproducing these drawings, but the preceding notes give their general characteristics.

The Collapse of the Bridge, Its Causes and Its Phenomena.

[Appendix 12.]

Concerning the actual occurrences in the collapse, the Commission finds:

The collapse came very suddenly; the duration of the fall was not over 15 sec. Those workmen who were on the bridge outside of the main pier and survived the fall all testify that they had no warning of any kind.

The cantilever-arm and suspended span fell as a whole. The big traveler fell as if it were part of the cantilever-arm, and did not upset, at least until after the arm had struck the water.

The anchor-arm fell almost without movement to the right or to the left. The lower chords, as well as the floor-system, fell without lateral movement. This is taken as proof of simultaneous failure in the two trusses.

The lower chords and floor-system of the anchor-arm show opposite longitudinal movements of the parts that were to the north and south, respectively, of the joint 8-9. This is proof that the initial failure took place close to this joint.

There was an almost complete destruction of the chords A 9 L and A 9 R, that of the latter being more striking and peculiar.

Measurements between anchor pier and main pier, after the fall, showed no change in position of the main pier. Levels on the main pier showed that it had risen slightly (0.011 to 0.014 ft.) when relieved of the load of the superstructure. The surveys thus demonstrated that nothing in the substructure or foundations contributed to the disaster.

The wreckage was investigated for the Commission by Mr. Walter J. Francis, M. Can. Soc. C. E., with instructions "to prepare such descriptions and photographs of selected bridge details as would be of service in assisting the work of the Commission." Some passages from Mr. Francis' report are quoted below:

Of more than 700 eyebars in the wreck, only one has been found which has broken, and on all the remain-

*For other parts of the Quebec Bridge Commission's Report see Eng. News, March 12, 1908, p. 288, Formal Findings; Eng. News, March 19, 1908, p. 307, Abstracts of Report and of Appendices 3 to 11 incl.; Eng. News, April 9, 1908, p. 404, Appendix 13 (Summary of Tests of Large Columns).

ing ones there is not a sign of a crack or failure of any kind. * * * The broken bar, 1 1/16 x 15 ins., is undoubtedly the result of a heavy blow on the edge about 18 ins. from the center of the pin. The bar parted about 4 ft. from the center of the pin, in acting as a beam [due to bending stress—Ed.]. The fracture is fine-grained, and although not of the highest class it would certainly be rated as good.

Of about 60 pins in the accessible parts of the debris, only one has any evidence of having been distorted. This pin is 12 ins. in diameter, 8 ft. 6 ins. long, bored 2¾ ins. diameter through its axis lengthwise. Its bend consists in having one end turned up about 5 ins., the curve being about 1½ ft. from this end. As this pin is at the joint where the eyebar above referred to was broken, its condition is undoubtedly due to the same cause as that which broke the eyebar.

Speaking generally, the compression members throughout have suffered severely. * * * The compression members are distorted in every conceivable manner, excepting at the panel-points, where the portions having internal diaphragms or outside covers are yet comparatively straight after enduring the forces of the fall. Between these stiffened portions the lattice work is torn, the laminated webs are parted, and the rivets sheared and pulled in every possible way.

The Commission itself says on this subject:

The principal feature to be noted is the comparatively uninjured condition of all members except some of the lower chords, posts and sub-posts which by reason of their position had to bear the larger portion of the forces developed by the fall, and completely failed under them.

All connections except the splices of the lower chords proved to be as strong as, and in most cases much stronger than the body of some of the members they connected. The tension members, laterals and floor system call for little comment; the compression members and their splices have shown themselves to be the weakest parts of the structure.

The crucial theme: The causation and progress of the collapse, as evidenced by the condition of the wreck, is treated by the Commission as follows:

We do not consider that any of the difficulties with lower-chord members noted previous to Aug. 1, 1907, were of serious moment, with the possible exception of the fail of chord A 9 L in the storage yard; the effect of that fall upon the latticing of the member was not determined, and in fact was practically impossible of determination.

Our investigations at Belair yard have convinced us that the several discrepancies noted in the chords during the earlier stages of erection were probably due to errors of shop-work, and, as Mr. Cooper said, were not serious. The waviness of the ribs which was often recorded by the inspectors might not produce serious results, its importance being dependent upon the strength of the latticing; (See Appendix No. 11) the presence of these bends would materially increase the stresses in the latticing, but we have no evidence to show that there was exceptional waviness in the chords that afterwards deflected most seriously.

* * * By the beginning of August the effect of the growing stresses on the weak end details of the chords became perceptible, and by the middle of August the chords began to show signs of failure in the body. On Aug. 6 the deflection of joint 7-8 L, cantilever-arm, was noted, and Mr. Kinloch has expressed his conviction that this deflection occurred after the lower cover plate was removed. The design of the chord ends and joints was such that it is probable that Mr. Kinloch's conclusion is correct, and that the removal of the lower cover plate weakened the joint appreciably. Any distortion at the joint would throw considerable stresses into the latticing unless the batten plates were of great strength and stiffness.

On Aug. 12 the inspectors reported a similar deflection at joint 8-9 L, cantilever-arm. On Aug. 8 the workman Haley noticed that the ribs at joint 8-9 R, cantilever-arm, did not match properly, and on Aug. 28 he noticed that the splice plates were bulging. This was noticed by Mr. Kinloch also, who was confident that they were all right when riveted. Haley also saw that chord 8 R, cantilever-arm, close to the joint just mentioned, was bending in all its ribs. The workman Beauvais noticed, during the two weeks previous to the accident, that the inner ribs at the joint 9-10 R anchor-arm were gradually coming together, but does not seem to have reported this. About Aug. 20 Mr. Kinloch noticed that chords 8, 9 and 10 R, cantilever-arm, were wavy in the body, but was not sure whether the bends were shop bends or not; he consulted Mr. Birks and they agreed that these waves were of no importance. On Aug. 25 the deflection at joint 5-6 R, cantilever-arm, was discovered.

On Aug. 27 the bending in chords 9 L, anchor-arm, and chords 8 and 9 R cantilever-arm, had become so noticeable that they were measured in detail, and reported to both headquarters. Mr. McLure's records note a deflection of ¾ inch in chord A 9 L about one week previous to Aug. 27.

This recital shows that the chords near the main pier both in the anchor-arm and in the cantilever-arm were under close observation for at least a week previous to the accident. These were the most heavily stressed compression members in the bridge.

We are satisfied that the structure was being closely watched and that had there been noticeable weakness at any points it would have been detected and recorded. There is no evidence of the existence of weak details except on the lower chord.

We therefore conclude both from the evidence of the witnesses, and from that of the wreckage, that the initial failure occurred in chords 9 R and 9 L, anchor-arm.

Our opinion is that these two chords failed almost simultaneously by rupture of latticing or shearing of lattice rivets, (See Appendix No. 17) and that the buckling of the ribs followed immediately. The cantilever-arm commenced to drop, turning around the feet of the center posts, and raising the anchor-arm near the point of rupture.

When the top of the center post had leaned over perhaps 30 ft. (this estimate being made by the witness Chase), the center post feet kicked off the pedestals, and both anchor and cantilever arms crashed down. The right truss of the anchor-arm apparently fell faster than the left truss, for the top members of the arm have fallen towards the right, and the witness Delphis Lajeunesse noticed such a movement. The stub chords on the cantilever side which were attached to the center-post feet struck the coping of the masonry heavily, the marks of the contact on these chords indicating that the right post was falling the faster.

The cantilever-arm was controlled in its fall by the stiffness of the center post, and by the resistance of the upper chord, and did not drop suddenly until the feet of the center posts kicked off the pier. The center post feet reached the ground first, carrying inwards before them the lower parts of panels 9 and 10 anchor-arm; the remainder of the anchor-arm was swung forward by the action of the upper chord in straightening out, under the pull of the cantilever-arm, and moved around the top of the anchor pier as a fixed point. The damage to the lower chords from the fall was the more severe because the ends of the posts landed in the foundation pits dug for the falsework, and the chords themselves struck on the high ground between the pits.

The forces that pushed the center post feet out into their present position, as described by Mr. Kinloch, are a matter of conjecture; the holes dug by the feet in their fall are plain to view and are partly filled by sections 5 of the center posts which are standing upright in them. As these sections are comparatively little injured and have not dug down into the ground, it is evident that they struck with but little force and that the ground was already shaped to receive them. The force of the fall was probably largely absorbed in the wrecking of sections 6 of the center posts.

The Stresses in the Bridge.

[Appendix 14.]

The Quebec Bridge was designed for a live load of 3,000 lbs. per ft. per track for unlimited length, Cooper's E 33 for lengths up to 900 ft., and Cooper's E 40 up to 550 ft. The bridge being double-track, the loads mentioned come on one truss. This low live-load and the high wind pressure, 50 lbs. per sq. ft., led the Consulting Engineer, Mr. Theodore Cooper, to base his check investigation of the design on various combinations of loading involving a greater vertical load and lower wind pressure, the combinations (half a dozen or more) being selected by him to represent possible or probable contingencies. One of the more important of these combinations was the following: Dead-load plus 1½ live-load, plus ½ wind, i. e., dead-load plus 9,000 lbs. per ft. of bridge (or 2 x 1½ E 33 or 2 x 1½ E 40, respectively) live-load plus 25 lbs. per sq. ft. wind pressure. As the stress intensities allowed by the original specifications were not as high as Mr. Cooper thought permissible, he set up the principle that if his check loadings gave stresses nowhere greater than 24,000 lbs. per sq. in. (reduced for column length over 50 r), the section provided would be acceptable to him. In amending the specifications for the bridge the stress of 24,000 lbs. in tension and 24,000 — 100 l/r in columns over 50 r long, was permitted for the loading: Dead-load plus 1½ live-load plus snow plus 1-3 wind. But various members showed higher stresses under other load combinations, as shown by the letters below. Some members, particularly the lower chord, gave stresses above 24,000 lbs., as the stress-sheet shows, but these were considered permissible for the particular members in question.

Drawing No. 4 [Fig. 1 herewith] has been prepared for the Commission and revised by the Phoenix Bridge Co. This drawing shows the maximum stresses arising from dead-load plus 1½ live-load plus ½ wind, this loading having been used to some extent in the original calculations at Mr. Cooper's direction. The only difference in the calculations leading up to the two sets of figures on the drawing lies in the dead-load used; for the first set the dead-load assumed in the designing was taken, and for the second the actual dead-load obtained from the built members. It will be noted that the error of stresses in the main chords near the center posts, due to this error of assumed dead-load, is fully 10%.

No satisfactory explanation of the occurrence of this error has been offered. On minor bridges, with a given live-loading, the weight of metal is known not to vary greatly with details of design, and in some offices revision of the assumed dead-loads for such bridges is not

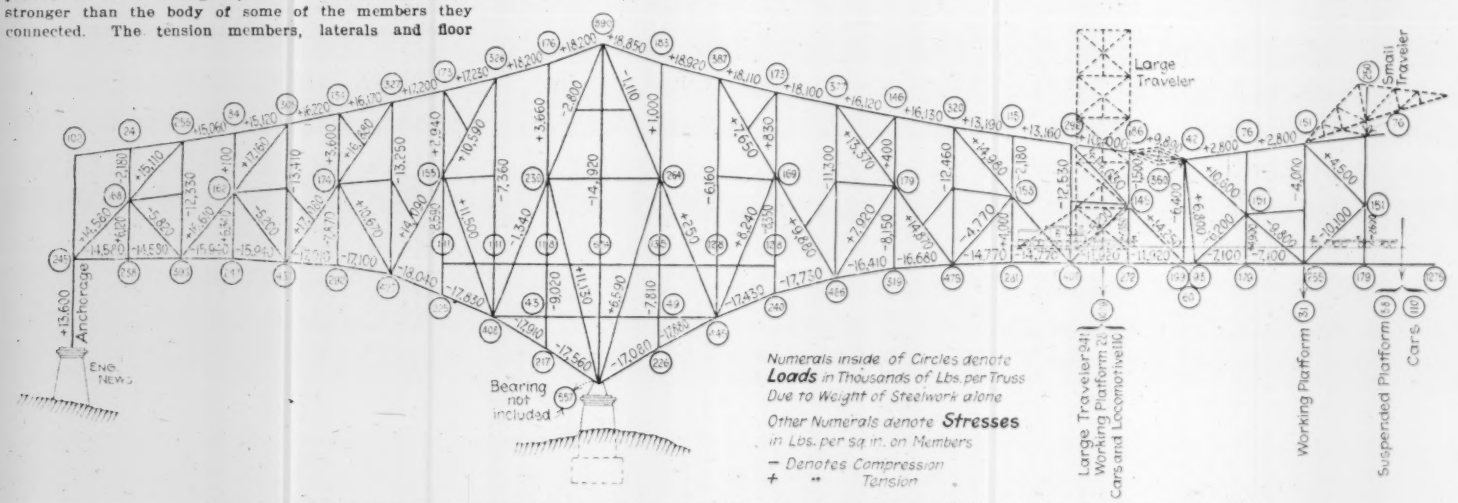

Large Traveler
Small Traveler
Anchorage
Bearing not included
Numerals inside of Circles denote Loads in Thousands of Lbs. per Truss Due to Weight of Steelwork alone
Other Numerals denote Stresses in Lbs. per sq. in. on Members
— Denotes Compression
+ " Tension
Large Traveler 241
Working Platform 20
Cars and Locomotives
Working Platform
Suspended Platform
Cars 110

FIG. 2. STRESS-SHEET OF QUEBEC BRIDGE FOR CONDITIONS AT THE TIME OF COLLAPSE, AUG. 29, 1907.
Computed by Phoenix Bridge Co., and Checked by C. C. Schneider, Consulting Engineer.

(Actual panel loads due to steelwork, travelers, engine, cars, etc., denoted by figures enclosed in circles, in thousands of pounds per truss. Add to this, for weight of track, 250 lbs. per lin. ft. per truss, = panel-load 12,500 lbs. in anchor-arm, 14,000 lbs. in cantilever-arm and suspended span. Stresses in pounds per square inch, + = tension, — = compression. The stresses are those due to loads as marked plus weight of track as noted.)

the rule; but no information from which to predict the weight of the Quebec Bridge existed and the probability of a serious mistake in the first estimate for weight would be apparent to a cautious designer.

The fact is that Messrs. Deans, Szlapka and Cooper permitted the shops and rolling mills to commence work without taking any steps to test the correctness of the assumed dead-load, and the probable dead-load does not appear to have been estimated from the plans until at least 18 months after the work of fabrication was commenced. * * * The work of designing was so far advanced by the beginning of 1905, that the preliminary estimates of dead-load might then have been revised with considerable accuracy. By reference to Appendix No. 8 [Eng. News, March 19, 1908, p. 308, col. 3], it will be seen that the percentage of error in the original estimates for all parts of the spans was roughly the same.

We are of opinion that no manufacturing should have been done until the designers had so far advanced with their work as to be able to make a proper estimate of the weight of the bridge. Before completing the drawings for use in the shop the weight of the various parts should have been computed as a check on the estimated weight of the bridge. As a matter of fact this procedure was not adopted, and manufacturing was commenced in July, 1904, without any such checking, although the specification called for it and the contract practically demanded it. The designing office had accumulated sufficient information to enable it to make a close estimate of the weight of the bridge, but did not do so. On the contrary, work continued as if their assumptions had been correct.

That Mr. Cooper fully intended to permit stresses in excess of 24,000 lbs. per sq. in. under the conditions used for drawing No. 4 is shown by the following letters:

Cooper to Szlapka, Aug. 6, 1904.

My dear Mr. Szlapka: I have tested the proportions of the members of the anchor-arm under the following maximum loading for my personal satisfaction—viz.: Dead plus 1.5 live plus 25 lbs. of wind (⅛ of your wind strain) and find that the only members exceeding 24,000 in tension or 24,000—100 *l/r* for compression are—

The lower chord which has 26,500 and is *all right* and Towers L which should have 108 sq. ins., and Towers B which should have 99 sq. ins., to come within the above conditions.

This is such a slight matter I request for the sentiment of the thing that you change those last two members to the above sections if it does not inconvenience anything.

(Signed) Theodore Cooper.

Szlapka to Cooper, Aug. 9, 1904.

Dear Sir: I have your kind letter of Aug. 6th in reference to increase of section of members "T L O O O O O" and "T B O O O O O O" for combination of stresses due to dead-load plus 1½ live-load plus wind.

I will gladly comply with your request and will also apply the same combination to all other members to satisfy myself that the unit stresses are in proportion not higher than those on the two above mentioned members. (Signed) P. L. Szlapka.

The propriety of the selected stresses is discussed in Appendix No. 18.

To supplement the stress-sheet Fig. 1, we also reproduce from the drawings accompanying the Commission's report the stress-sheet, Fig. 2, which gives the stresses existing in the main members of the trusses at the time the bridge collapsed, Aug. 29, 1907. The figures given on this sheet were calculated by the Phoenix Bridge Co. and checked by Mr. C. C. Schneider, M. Am. Soc. C. E., as Consulting Engineer for the Department of Railways and Canals of Canada.

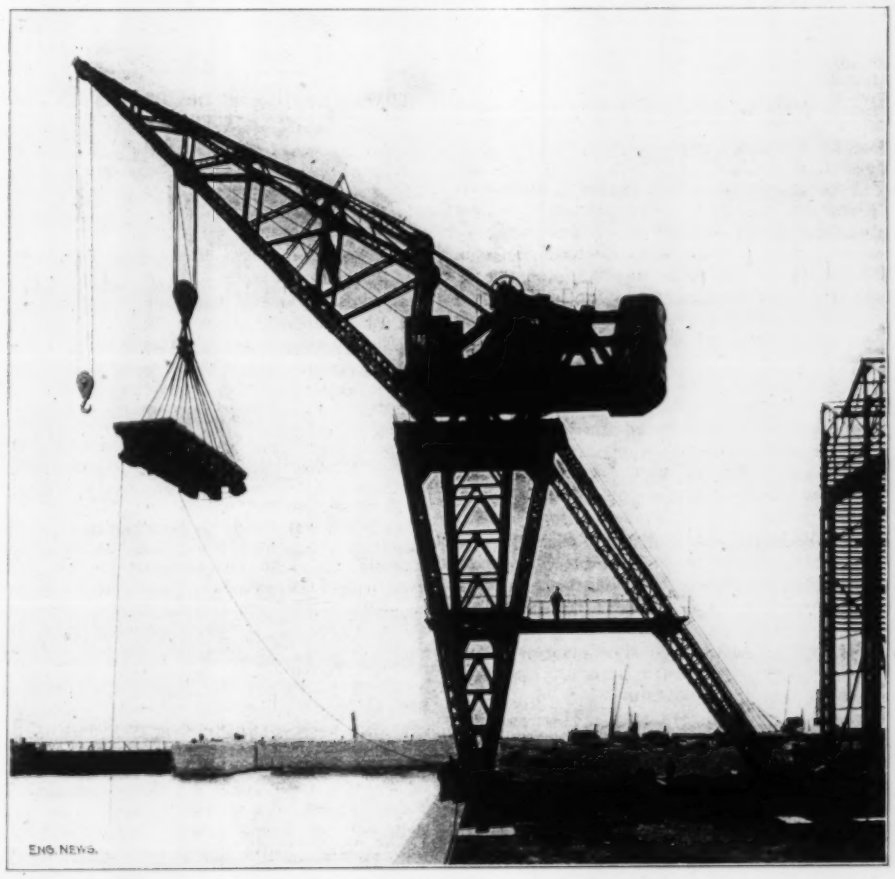
The stress-sheet Fig. 2 is based on the actual panel concentrations denoted (in thousands of pounds per truss) by figures enclosed in circles. These dead-loads represent the weight of the steel work only. The weight of the two travelers, and of locomotive and cars, etc., as they were on the bridge at the moment of collapse, are also noted on the drawing (in thousands of pounds per truss). The dead-load from which the stresses were computed includes further the weight of floor timber, etc., amounting to 250 lbs. per lin. ft. per truss, or 12,500 lbs. per panel per truss in the cantilever-arm and suspended span, which is not included in the figures surrounded by circles.

Fig. 2 shows that the chord stresses on the day of the collapse reached a maximum of nearly 19,000 lbs. per sq. in. tension in the top chord, and slightly over 18,000 lbs. per sq. in. compression in the bottom chord. The stress in bottom chords 9 of the anchor-arm, the chords which the Commission charges with causing the collapse, was 17,910 lbs. per sq. in. This is just three-fourths of the 24,000 lbs. which these chords were intended to bear in service, and about three-fifths of the stress which they might have received under the loading of Fig. 1.

AN ENGLISH 150-TON WHARF CRANE.

A 150-ton crane, which is intended for handling ships' boilers and machinery, and which presents some interesting features, has recently been erected at the dock at Tranmere (England). The crane proper is of the tilting type, and closely resembles the 140-ton crane illustrated in our issue of Aug. 29, 1907, but instead of being mounted on a float or pontoon, it is mounted on a 60-ft. steel tower. The machine consists of two principal parts: (1) the stationary frame or tower; (2) the revolving upper portion, the vertical supporting leg of which is enclosed within the tower. In this latter feature of the design the crane resembles the building crane or derrick described in our issue of July 25. The crane can revolve through a complete circle.

The tower rests on three feet (52 ft. 6 ins. apart), which are carried by foundation blocks, and connected by horizontal members at the ground level. A fourth block carries the revolving column, the upper part of which is steadied by guides at the top of the tower. This column is of tapering form in the lower portion and broadens out above the pressure-ring at the top in order to carry the driving gear. At the right of this the counterweight is carried on a short arm; and at the left the foot of the boom is attached. The boom commands a working field between two concentric circles of about 28 ft. and 88 ft. radius. The tackle at the end of the boom is designed for loads up to 50 tons, while the tackle situated lower down will carry working loads up to 150 tons.



AN ENGLISH 150-TON SHIPBUILDING AND DOCK CRANE.

The machine is operated by electricity, direct-current being adopted in order to make use of the valuable properties of series-wound motors. The current is brought through contact-rings above the platform, fitted about half-way up the tower. The driving-gear is all placed in the revolving portion of the crane. The revolving load is entirely carried by the centre foundation, and the suspended weight produces a tipping moment, which is resolved into two horizontal forces; one of these acts at the foot of the revolving column, and the other at the pressure ring at the top of the tower. In order to carry the direct vertical load, a combined spur and bolster bearing, working in oil, is placed in the centre foundation. At the upper part of the tower the tipping forces are taken by a roller bearing.

The turning gear consists of two equal driving gears, each driven by a separate motor. The motors work on two worm gears with quick threads, which transmit the movement through pinions to spur-wheels which act upon the driving-rack fitted to the pressure ring. The two lifting-gears are placed on the main platform. For the 50-ton lifting-gear, a six-rope tackle is used, the ends of the steel rope being simultaneously wound on two drums of large diameter. The lifting-gear for the 150-ton load also has two drums, each of which winds up one line of the 10-rope pulley. The gearing between the drums consists entirely of spur wheels. In order to hold the load and the driving-gear when uncoupled, powerful band-brakes are provided. The load-hooks revolve on ball bearings.

The topping or derricking movement is performed by means of two heavy steel screws forming an extension of the top chords of the boom. They are fitted to nuts on the boom in such a manner that when the screws rotate the boom is thrust forward (and lowered) or pulled back (and raised). The boom revolves on pins at the ends of the bottom chords for this movement. The two screws are fitted with bevel wheels, which gear with similar wheels on a shaft at the top of the tower. Motion from the motor is transmitted to this shaft by further gearing. The screws are served by an electro-magnetic band-brake. The control of the crane is effected from the operator's cabin, which is placed on the forward portion of the main platform, 65.6 ft. above the ground. The reach of the boom at any time is indicated by a pointer on a dial.

The following motors are employed: Two of 12.5 HP. (500 r.p.m.) for turning the crane; one of 110 HP. (430 r.p.m) for lifting the load; one of 57 HP. (500 r.p.m) for topping the boom. The speed for the 150-ton hoist is 5 ft. per minute with full load, or 8¼ ft. without load. The speed for the 50-ton hoist is 19¼, and 30¼ ft. per minute with and without load. The crane

can make one complete revolution in from 5 to 7 minutes. The topping of the boom (with load) from the greatest to the smallest reach occupies from 10 to 15 minutes. The weight of structural steelwork in the crane is 305 tons, and the counterweight weighs 162 tons. For the above information we are indebted to Mr. J. B. Van Brussel.*

FURTHER TESTS ON THE USE OF DENATURED ALCOHOL IN GASOLINE ENGINES.

The extensive tests of the U. S. Department of Agriculture on alcohol as a fuel for use in explosion engines which were reported recently in these columns† have been supplemented by tests made for the Technologic Branch of the U. S. Geological Survey under the direction of Mr. J. A. Holmes. Prof. R. H. Fernald and Mr. R. M. Strong conducted the tests, using the equipment of the fuel-testing plant of the Geological Survey, now at Norfolk, Va. There were more than 2,000 individual tests in the series. The comparison was between gasoline of 73° specific gravity and commercial fully-denatured alcohol. The principal conclusions which the tests yielded are as follows.

FUEL CONSUMPTION.—Correspondingly well designed alcohol and gasoline engines, running under the most favorable conditions, will *consume equal volumes* of their fuels. But while the possibility of this has been shown conclusively, it yet remains with the engine builders to realize the "equal volumes of fuel" in practice.

The average of the minimum fuel consumption values given by the tests was 0.8 pint per B. HP.-hr. for both gasoline and alcohol.

THERMAL EFFICIENCY.—It is to be noted that the heat value of denatured alcohol is only about 6-10 that of gasoline, volume for volume, so that the alcohol engine developed the higher thermal efficiency. The maximum efficiencies for the two fuels, calculated from the brake horsepower and the lower calorific value (19,100 B. T. U. and 10,500 B. T. U. per lb., respectively), were 22.2% for gasoline and 34.6% for alcohol.

MIXED VAPORS.—A mixture of gasoline and alcohol vapor, by the use of a double carbureter, gave efficiencies ranging between the preceding figures, but in no case higher than that for alcohol.

PREHEATED AIR, ETC.—The principal tests were made without preheating the air and with the use of ordinary constant-level suction-lift carbureters and constant-level pressure-spray carbureters. But tests were also made with special carbureters, and with air preheated to various temperatures up to 250° F., and they showed no better results under the test conditions (including constant speed and best load).

LOWER-GRADE ALCOHOL.—Special tests were made with alcohol (and water) of various percentages of strength, from 50% to 94% by volume. The fuel consumption increased a little more rapidity than the per cent. of pure alcohol decreased, i. e., the thermal efficiency decreased as the strength of the alcohol decreased; but this decrease is slight from 100% to 80% alcohol, and the minimum consumption (by volume) was only about 17.5% greater with 80% alcohol than with the denatured alcohol or with gasoline.

The maximum power which a given engine can produce is greatest with the purest alcohol; with the 80% alcohol it was reduced about 1%.

The difficulties of starting and regulation were appreciably greater with the 80% alcohol.

EFFECT ON CYLINDER AND VALVES.—The denatured alcohol used consisted of 100 parts ethyl alcohol plus 10 parts methyl alcohol plus ½ part benzol, corresponding very closely to 94% by volume or 91% by weight ethyl (grain) alcohol. The use of this fuel produced no detrimental effects on cylinder walls or valves.

DEGREE OF COMPRESSION.—The lowest fuel consumption was obtained when the highest practical degree of compression was used, 150 to 180 lbs. per sq. in. above atmosphere for the denatured alcohol.

USE OF ALCOHOL IN GASOLINE ENGINES.—Commercial gasoline engines of stationary or marine type will consume from 1½ to 2 times as much alcohol as gasoline, when operating under the same conditions. To obtain the best results with alcohol, these engines require changing; this, however, is not entirely practicable, chiefly because it is usually difficult to raise the compression sufficiently, and because the engines are not always built heavy enough to stand the maximum explosion pressures (600 to 700 lbs. per sq. in.).

RELATIVE WEIGHT AND POWER.—An engine specially designed for alcohol will be heavier than a gasoline engine of the same size, but it will have about 35% greater power capacity, so that the weight per horsepower need not be greater.

The gasoline engines used in the tests were representative American stationary engines of 10 to 15 HP., running at 250 to 300 r. p. m. The alcohol engines were of similar construction and the same size.

*P. O. Box 293, Brussels, Belgium.

†Tests of Gasoline and Kerosene Engines with Alcohol Fuel," by S. M. Woodward, Eng. News, March 12, 1908, pp. 271-275.

CHARACTERISTICS OF THE FRANCIS HYDRAULIC TURBINE.

By W. F. UHL.*

[The following remarks, reprinted from the "Journal of Electricity, Power and Gas," of March 28, may be taken as a discussion of the paper by Mr. J. H. Wise, Assoc. M. Am. Soc. C. E., on the Centerville (California) installation of a high-head Francis Turbine. They are, in a way, a reply to the discussion on that paper by Mr. H. Homberger, printed with Mr. Wise's paper in Engineering News of March 19.]

Up to date the writer has designed or has been intimately connected with the design and operation of 85,200 HP. of high pressure reaction turbines, ranging in size of units from 875 HP. to 13,500 HP. capacity, and operating under heads from 270 to 550 ft. and in connection with pipe lines ranging in length from 500 ft. to 5 miles, the water in them having a velocity as high as 25 ft. per sec.

The points which seem to have been given most consideration by the various engineers who discussed the 9,700-HP. Centerville turbine are as follows: Purchase price, regulation, efficiency, dirty water, economy and maintenance. We will try and take up these various points, giving our experience regarding them, but we do not maintain that other engineers may not have had contrary experiences.

PURCHASE PRICE.—The price of the turbine, governor, pressure regulator and generator suitable for the conditions under which the Centerville turbine operates is approximately $37,000, f. o. b., works. It occupies with its auxiliaries and generator a floor space of 429 sq. ft. It is a well-known fact that the efficiency of the turbine depends upon the specific speed or the speed for unit head per unit of power. Impulse turbines having the same relative specific speed as the Centerville reaction turbine which has a speed of 400 r. p. m. would require four nozzles of 7 ins. diameter jet each. Since it is mechanically inconvenient to use more than two wheels for one unit and inefficient to use more than one jet on each wheel with horizontal units we would require two units for the same output. With the given specific speed each unit would have a speed of 200 r. p. m. The price of two such units of the deflecting nozzle type with suitable governors and generators is approximately $60,000, and the floor space occupied is 1,800 sq. ft. If the reaction turbine is operated with the pressure regulator used as a synchronous bypass, giving the same results as the deflecting nozzle, the economy of the turbines is practically the same, but the hydraulic efficiency is in favor of the reaction turbine. A correctly designed pressure regulator can be arranged to vary its discharge the same as a hand-operated needle nozzle.

REGULATION.—The type of turbine has absolutely no effect upon the regulation of the speed of a hydroelectric unit. When the pressure regulator operates as a synchronous bypass the velocity of the water in the pipe line will be constant, as with a deflecting nozzle impulse turbine, and the regulation depends upon the governor and the flywheel effect only. If the governor is of proper design, its regulation depends entirely upon the flywheel effect of the rotating masses, the same as with a steam or gas engine. If the pressure regulator is used automatically so that it will only open for certain predetermined changes of load (as a well designed pressure regulator must operate), the regulation depends also upon the pressure increases and decreases in the pipe line. But these conditions again remain the same with a reaction turbine as with an impulse turbine, providing the impulse turbine also has automatic pressure regulators which every impulse turbine, to operate as economically as the reaction turbine, must have for the same length of pipe line. There is no reason why pressure regulators should not be used with impulse turbines as well as with reaction turbines. There is no excuse for the deflecting nozzle impulse turbine unless it is necessary to pass the same amount of water regardless of load as may be the case where power plants are operated in conjunction with irrigation projects, or where it is impossible to provide a suitable standpipe on an exceptionally long pipe line.

EFFICIENCY.—From tests so far made on a suitable number of impulse and reaction turbines of numerous makes, we are satisfied that the reaction turbine has the advantage of at least 3 to 4% with heads from 200 to 600 ft. What higher heads will produce is yet to be determined, but indications are in favor of the reaction turbine. With an exceptionally well designed impulse turbine 82 to 83% may be obtained as against 85 to 86% with the reaction type. The maximum point of efficiency can be arranged to occur at half gate as well as at full gate, and the efficiency is not necessarily the best at normal gate opening.

DIRTY WATER.—When the first reaction turbines were built it was assumed for no apparent reason, that dirty water would wear out the turbine parts rapidly. This assumption has proven erroneous, and such parts as have so far shown wear, have been proven to be defective in design, and the wear was in no case due to dirty water. That this should be the case may be readily seen from the fact that the highest velocity the water reaches in a reaction turbine is about $0.67\sqrt{2gh}$, whereas with the impulse turbine the water reaches a velocity of $0.95\sqrt{2gh}$. Furthermore, any debris which can pass through the nozzle of an impulse turbine can certainly pass through the reaction turbine.

ECONOMY.—If both types of turbines are provided with automatic governor actuated pressure regulators, the economy should be the same, but with the pressure regulator used as a synchronous bypass on the reaction turbine, it is more economical than the deflecting nozzle type, since the bypass can be arranged to be automatically adjustable, whereas the needle must be operated by hand.

MAINTENANCE.—A reaction turbine, due to its construction, is much more adaptable to good substantial mechanical design than either the deflecting nozzle, hand-regulated needle type, or the stationary nozzle type with governor actuated needle and pressure regulator. There is no excuse for any part of a reaction turbine breaking since there is no part where it is necessary to use a small factor of safety to gain small weight. The design of the runners themselves is very compact and solid in one piece, with no parts being held together by bolts, whereas the impulse turbine wheel has many component parts, and it is a noteworthy fact that many wheels have broken with disastrous results.

Regarding multiple nozzle impulse wheels; it is not possible to make a good design with more than one nozzle for a single horizontal unit. With vertical units, it is possible to make a number of nozzles to one wheel, but this brings into question the thrust bearing, and the higher the speed the less desirable is the thrust bearing of the vertical type, since the rotating parts cannot be balanced as is possible with the reaction turbine.

Oil lubricated thrust bearings give no more trouble than a ring oiling horizontal bearing but their sphere of usefulness is limited and our experience will not permit us to recommend oil pressure thrust bearings. They are unreliable, and a spare unit must be at command at all times; furthermore, the maintenance of an elaborate oil pumping system, which must be in duplicate to be safe, is an item which often means the difference between dividends on an investment and the failure of it.

Draft tubes for impulse turbines, or for that matter, with any type of turbine other than the reaction turbine have not proven a success, and as far as we know, they are a waste of money. A properly designed draft tube with a reaction turbine, although not necessary, provides for a change in the tail water level, and since it is necessary to place the lowest point of impulse wheel above the highest tail water, which occurs usually for only one or two days in a year, a large percentage of the total head is lost at all times, since the head water almost always varies with the tail water, leaving the total head the same. The head usually lost with an impulse turbine is about 20 ft. For the same amount of water, therefore, under 550-ft. head we lose 300 HP. on the 9,700-HP. turbine, which, at $30 per HP., per year, means a loss of $9,000 net.

*Engineer, Hydraulic Turbine Department, Allis-Chalmers Co., Milwaukee, Wis.

AN INLAND WATERWAY along the New Jersey Coast is to be built by the State of New Jersey, according to a bill signed by Gov. Fort on April 6. The waterway is to extend from Cape May to Bay Head and is to be 100 ft. wide and 6 ft. deep. Not more than $300,000 is to be expended in any one year.

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Entered at the New York Post-Office as Second-Class Matter.

Congress enacted last week a new Employers' Liability law, covering workmen engaged in interstate commerce, to take the place of the one recently declared unconstitutional by the U. S. Supreme Court.

As our readers know, Engineering News has repeatedly urged radical reform in our employers' liability legislation on the lines adopted by every industrial nation except the United States. We are obliged to say, however, that the act passed by Congress last week appears to be a step backward instead of a step in advance. It passed Congress almost without debate and appears to be intended chiefly for campaign purposes. Actually, however, it is a law for the benefit of attorneys who push damage suits—the ambulance-chasing branch of the profession—rather than for the benefit of labor.

Briefly stated, the bill provides that railway companies shall be liable to their employees who suffer injury by reason of the company's neglect, and that in defending such damage suits the company cannot plead that the injury was due to the neglect of a fellow employee or the carelessness of the person injured.

In other words, the new law lets down the bars by which the companies defend themselves against all manner of unjust and exorbitant strike suits and provides no defence to take their place. An expensive lawsuit is still necessary to settle every claim for damages, and of the amounts which the railways are mulcted, the great bulk will go to pay the lawyers and other expenses of litigation.

The leading railway men of the country, instead of blindly fighting President Roosevelt's proposal for a just and equitable system of employers' liability, ought to have joined hands to secure the enactment of a sound and proper measure, one which would largely eliminate the vast sums now spent on litigation and divert them instead to the relief of the thousands of deserving employees who suffer injury and receive no aid to bear their burden.

For three months past, following the publication of a sensational magazine article, the press has been filled with criticisms of the U. S. Navy. We have not thought it worth while to give space to any of the voluminous discussion. To those who could see beneath the surface, it has been evident that these criticisms of the navy and of our naval vessels originated partly from a desire to make political capital, partly from the desire to make money by exploiting sensational articles in the press and partly from some jealousy and prejudice inside the Navy Department. Eliminate all these and there still remains doubtless some fair and reasonable criticism in all that has been uttered; but it has been so buried out of sight in the torrent of destructive slander and vituperation that it might better have been postponed to a more suitable season.

No one supposes that the navy organization is perfect. Doubtless it is true that the different bureaus do work more or less at cross purposes; but we hear exactly the same complaint of lack of departmental cooperation from inside prominent railway and industrial corporations. Human nature is not materially different in the navy and out of the navy.

No one supposes, either, that any battleship or other naval vessel is perfect. Far from it. The modern naval vessel is in its design a compromise and must be, absolutely, from the necessities of the case. Of course the line officer wants his vessel to have more and bigger guns, thicker and wider and longer armor belt, higher speed, greater coal capacity, more roomy quarters for its crew. The naval designer has to take a certain limited number of tons displacement and provide as much speed and armor and offensive power and all the rest as the conditions permit.

A large part of the criticisms which have been aimed at our battleships and their designers during the past few months have referred to the location of the armor-belts. It has been repeated over and over again that the armor-belts were too low; that the tops of the belts were under water when the ships were ready for sea with all coal and stores on board; and the naval designers have been called impracticable theorists, ignoramuses, bureaucrats and various other uncomplimentary names.

This sort of criticism reads well in the pages of a popular magazine, and perhaps it will make good political campaign documents; but when it is examined with a little practical knowledge, how puerile it appears!

A ship may have to fight a battle when its coal and stores are nearly exhausted and it stands high out of the water in consequence. The Battle of Santiago was fought under exactly those conditions. Again, there can be no certainty that battles will be fought in smooth water, and in a seaway all ships roll more or less. The critics who have been barking themselves hoarse against our naval vessels have been vociferous in their assertions that Admiral Evans himself "had it in" for the designers who had placed the armor-belts so low. It was freely asserted that when he arrived, after completing the cruise around the South American continent, he would add the weight of his authority on the side of the critics. But when he at last arrived and the impatient reporters sought to draw him out on the armor-belt question, "Fighting Bob" assured them that while he would be glad to have the top of the armor-belt raised so as to give more protection, on the other hand the vessels of his fleet often rolled until the bottom of the armor-belt was raised above the water line.

And so, as Mr. Dooley says, there you are! There is absolutely not a shred of evidence in all that has been published, so far as we have seen, to show that our naval designers have not done the best possible within the necessary limitations. They appreciate, what the general public and possibly the naval critics do not, that every inch the armor-belt is raised materially affects the stability of the vessel. They appreciate, what the critics of the navy apparently do not, that while higher armor-belts, higher freeboard and higher batteries might have possible advantages, the first duty of a designer is to guard the stability of his vessel. A battleship must be safe against capsizing in any ocean storm. Besides this, if a higher armor-belt so decreased stability as to cause greater rolling, the vessel might expose still more of her bottom below the armor to the enemy's guns when fighting in a seaway.

CONCERNING ENGINEERS AS MEMBERS OF COMMISSIONS.

A correspondent calls attention to the following published remarks of the Mayor of Baltimore relative to a proposal to place certain public work under control of a commission made up of engineers:

> It would be almost impossible to get a commission composed largely of engineers to agree on anything. We do not want a commission that will spend all its time wrangling over technical questions. We want a commission that will go ahead and do things, even though, as happens in the best regulated families, mistakes do happen once in a long while. A commission of laymen, if it starts out by engaging the best engineering talent, will accomplish more results in a given time than a commission of engineers.
>
> It is the almost universal rule among business corporations in this country to put laymen—men of affairs—on their boards of directors, and then engage the services of experts to handle the operating departments, the mills, engineering works or the like. A technical man on a board of directors in a private business corporation is generally a nuisance; a board composed entirely of technical men is almost always a failure.

Is this a just stricture on engineers? Does professional training and experience in engineering work unfit a man for larger responsibilities? Of course, it is true that a man may be competent as an engineer and yet be incompetent to pass upon the large questions which may come before an important commission or the board of directors of a large corporation. But that is not the question; the question is whether an engineer who has the ability to do good work as a member of a commission is actually made less fit for such work by his professional knowledge.

One would suppose that merely to state such a problem would be to answer it. If a city is to build a water supply system, ought it not to get better work for less money, if it turned over the work to a commission of three eminent engineers, than it would do if it turned it over to three grocers, or three lawyers, or three professional politicians?

As our readers know, we have long advocated the appointment of engineers on public commissions having to do with engineering matters, and we still believe in that policy, not from the standpoint of giving engineers employment, but because the public needs their services.

In support of this policy we can cite many instances where important enterprises have been successfully carried out under commissions of engineers. We can also cite instances where commissions dealing with technical matters have been made up of men wholly ignorant of such matters and the work or the public treasury has suffered greatly as a result.

And yet we have to frankly admit that there have also been cases where engineering commissions have "made a mess" of their work. Some cases of this, indeed, have been brought so prominently before the public that the reputation of the profession has unquestionably been more or less impaired, and a foundation is afforded for broad indictments of engineers as a class, such as that quoted above.

There is, we believe, this much justification for Mayor Mahool's statement: That a commission made up of engineers is liable to one error which a commission of laymen could not well make, and that error is *the usurpation of executive functions.*

There is a very common misunderstanding of the real duties of a commission created to construct, let us say, some important engineering work, such, for example, as the Boston Rapid Transit Tunnel. Actually such a commission's duties are *legislative* and *not executive.* Its business is to decide questions of general policy, adopt general rules, scrutinize the work of its chief executives; but so long as they "make good," by all means keep its hands off. Wherever a commission departs from this rule, attempts to deal itself with matters of detail and relegates its chief engineer to the position of a chief clerk, trouble may surely be expected.

Now a commission made up of engineers is often strongly tempted to make errors of this sort. Where a board made up of grocers or bankers would give the chief engineer a free hand, in ignorance whether his work was good or bad, a board of engineers is very apt to see where in the opinion of one or another of the board, the engineering work could be bettered, and so they interfere when interference is not necessary and may very likely be injurious.

We believe errors of this sort proceed from a failure to understand the true limitations of a commission's field of work and not because engineers as a class are more disposed to quarrel and haggle over trifles than are merchants or bankers.

A great deal was said a year or two ago about the necessity of placing the Panama Canal work in the hands of one man with unlimited powers instead of in the hands of a commission. We heard much of the necessity of concentrating authority in the hands of one man in order to get things done. Statements of this sort are based on a sound principle and rightly interpreted they do not conflict at all with that other sound principle expressed in the old maxim that "in a multitude of counselors there is safety." Executive authority *should* be concentrated in one man. Two chief engineers on a work are one too many. On the other hand, the large problems of general policy ought to be determined by the united wisdom of an assembly, and not by a single individual.

In any organization for the conduct of business, either private or governmental, there is both legislative work and executive work to be done; and the two departments should each keep to its own proper duties. When Congress, or a State Legislature, or a board of directors of a corporation, or a commission for carrying on a great public work leaves its own proper duties and attempts to prescribe in minute detail how this or that or the other executive officer shall perform his work, the almost certain result is that the legislative work will be neglected. Examples of this evil are before the country daily. Committees of Congress haggle over trifling items in an appropriation bill which ought to be left to the discretion of the Executive Department, and consequently, they have no time to spare for action on matters of real national importance. The Panama Canal Commission of 1902 attempted to legislate on such trivial matters as raising a stenographer's salary. Naturally, it found itself so overwhelmed with work that matters of grave importance were subjected to serious delay.

On the other hand, in Massachusetts, which has had notable experience in the conduct of public work through commissions, there have been many cases where engineering commissions have been placed in charge of engineering work and the members have been wise enough to place executive responsibility for engineering matters on their chief engineer and refrain from interference with him.

LETTERS TO THE EDITOR.

Heaving of Masonry by Frost.

Sir: Certain military engineers of one of the great powers of Europe experienced the same trouble as that related by Mr. Edwd. H. Rigby, Tientsin, North China, in your issue of March 5.

After great damage and many costly experiments sheet piling was tried and proved to be a success. In the first trials they used pitch pine boards 0.08 × 0.30 meters driven at an incline to the vertical axis of the masonry and to a depth of 1.50 to 3 meters below established frost line and at a distance convenient to obtain the necessary inclination (this inclination by the way was subject to a great many experiments, as it was found to be a very important factor; I am unable to give the results of these experiments, and do not think that they would apply to all conditions of earth as the ground in this case was particularly bad and also marshy).

The engineers have now abandoned the use of wood for piling, as it required constant renewal on account of splintering caused by compression; they now use steel only and of a pattern not found in the market. As far as I know, no further trouble by frost-heaving is experienced. S. A. I.

Xcalak, Quintana Roo Ter., Mexico, March 25, 1908.

The Grant-Mitchell Irrigation Ditch Water Meter.

Sir: Referring to the letter from Mr. Elwood Mead, published in Engineering News of March 26, 1908, in regard to the Grant-Mitchell irrigation ditch water meter, which is being used in Australia: The Water Resources Branch of the Geological Survey constructed one of these meters with the idea of having it tested for use in the U. S. Reclamation Service. Complete tests, however, have not yet been made, but it is believed that this type of meter will give a practical solution of the problem of the measurement of water in distribution systems for irrigation work.

In the model of the meter made by the Survey a propeller wheel-head, similar to that on the Haskell meter, was used in place of the blades, as shown in Fig. 1 of Mr. Mead's letter. This wheel will allow any debris to pass through without interfering with the working of the instrument.

Messrs. W. & L. E. Gurley, Troy, N. Y., have recently arranged with Messrs. Grant and Mitchell, the patentees of the meter, to place the instrument on the market in the United States and are now constructing a test meter.

Yours truly,
John C. Hoyt.

1330 F St., N. W., Washington, D. C., March 30, 1908.

The Time to Save the Remnants of the Appalachian Forests from Destruction is Now.

Sir: Unwillingness on the part of the leaders of Congress to permit legislation at this session beyond the regular appropriation bills works particular hardship in the White Mountains. The protective forests on the high slopes have been going at the rate of 300 acres daily or 25,000 annually, which affects the agricultural, manufacturing and navigation interests throughout New England.

The bill for National Forests in the White Mountains and the Southern Appalachian Mountains has been endorsed by the entire country. Lumbermen and papermakers, farmers and business men, and the press, without exception, have urged this measure for five years. Two years ago it passed the Senate and was recommended unanimously to the House of Representatives by the Committee on Agriculture, but owing to the opposition of the Speaker did not then become a law.

At a recent hearing before the present Committee on Agriculture, the Governors of Georgia and New Hampshire, with official delegates from the governors of twelve other states, and a group of two hundred business men and citizens from all of the states east of the Mississippi, except four, presented evidence that the timber supply is disappearing, that water powers are affected, that navigation is crippled, and that agriculture in the low lands, particularly in the South is, in many cases, wiped out by floods. Delegates from the Pittsburg Chamber of Commerce showed that recent floods cost that city ten million dollars. Lawrence, Mass., sent a delegation, including the Mayor and the President of the Board of Trade, to show the importance of the Merrimac for drinking water, as well as for power. To all these Congress apparently has turned a deaf ear.

When the matter came before the Judiciary Committee, the Governors of Massachusetts, Connecticut and North Carolina sent able lawyers to Washington to prove that the matter is one in which Congress has undoubted power to act.

Neither the Committee on Agriculture nor that on Judiciary has made any report and the impression prevails at Washington that they do not intend to do so. Is there any reason why the leaders in the House of Representatives should longer obstruct the will of the people? When six New England states and eight Southern states unite in asking prompt action by Congress do the men who guide that body propose to turn the matter calmly down? What do the representatives from the South and from New England intend to do about it?

We ask the cooperation of your paper *to secure action at this session of Congress.*

Very respectfully yours,
F. W. Rollins,
President of the Society for the Protection of New Hampshire Forests.

Concord, N. H., April 4, 1908.

[Accompanying this letter is an appeal from eleven of the largest manufacturing companies in New England, addressed to the members of Congress from the New England States, and reading as follows:

We have heard with regret and alarm that the White Mountain and Appalachian Forest Reserve Bill (H. No. 10457) may not be enacted at this session of Congress.

We beg to say that we believe the future welfare and prosperity of the eastern part of the United States and especially of New England to be dependent upon the adoption of the policy set forth in this bill, and that if such policy is not adopted now it will be necessary to adopt it at a future time and at vastly increased expense, and that in the meantime great injury will be done New England.

We therefore earnestly ask for your combined and active interest in and immediate support of this bill to the end that it may become a law at this session of Congress.

If the fleet of a foreign power were to appear off our coasts, can one imagine Congress haggling session after session and year after year over the question whether anything should be done for protection against the enemy? Yet the destruction of the Appalachian forests will cause loss and damage quite comparable to and more lasting than that which any hostile fleet could effect, and yet—to paraphrase W. S. Gilbert—

> "Our House of Lords with one accord
> Does nothing in particular
> And does it very well. [?]"

The United States has passed the stage when the national demand for positive action by our legislative body to protect the public interests can be safely ignored. Congress will be derelict in its duty if it adjourns without taking action on the Appalachian Forests Bill.—Ed.]

Notes and Queries.

Referring to the 7-story freight warehouse in Newark, N. J., illustrated in our issue of March 26 (p. 340) Mr. F. E. Pratt calls attention to a freight house which almost exactly duplicates this structure and was erected three years ago near the intersection of Jay and John Sts., on the East River water front in Brooklyn.

We are authoritatively informed that no definite steps have been taken toward installing dry-air blast equipment in the blast-furnace plant of the Tennessee Coal, Iron & Railroad Co., at Ensley, Ala. The note on p. 384 of our issue of April 2, 1908, stating that such equipment is soon to be put in, is therefore to be interpreted as meaning that the matter has been discussed but has not yet reached a stage where the improvement can be said to be in active contemplation.

In our issue of April 2, 1908, p. 368, we credited the firm of Wortham & Washington, of Greeley, Colo., with the construction of a revolving pile driver therein described. We have since learned from Mr. Wortham of the above firm that the design was made by himself and Mr. John McRae when they were in the employ of the Union Pacific Ry. and the construction was carried out by the railway company for use on their bridge over South Platte River at Evans, Colo.

THE NEW STEEL RAIL SPECIFICATIONS OF THE PENNSYLVANIA R. R.

The new specifications for steel rails adopted by the Pennsylvania R. R. were made public on April 11 and are printed in full below. These specifications have been drafted by a special committee of the company's officials appointed in June, 1907, and made up as follows:

Theo. N. Ely,	Chief of Motive Power, Lines East and West, Chairman.
A. C. Shand,	Chief Engineer, Lines East.
L. R. Zollinger,	Engineer Maintenance-of-Way, Lines East.
A. W. Gibbs,	Gen'l Supt. Motive Power, Lines East.
C. B. Dudley,	Chemist, Lines East.
T. H. Johnson,	Consulting Engineer, Lines West.
Robt. Trimble,	Chief Engineer Maintenance-of-Way, Lines West.
W. C. Cushing,	Chief Engineer Maintenance-of-Way, Lines West.
J. C. Bland,	Engineer of Bridges, Lines West.
D. F. Crawford,	Gen'l Supt. Motive Power, Lines West.

To make a practical test of the work of the committee, the company placed, in December, 1907, an experimental order for 10,000 tons of rails—a part of the 1907 allotment—to be rolled in accordance with the new sections and specifications. The experience in rolling these rails resulted in some slight changes in the specifications, but no change has been made in the sections as originally adopted. The Pennsylvania System has adopted as a standard for its 1908 orders the new sections and the specifications as revised Feb. 4, 1908.

A uniform system of blanks and reports has been devised whereby a full history of all rails purchased by the company will be fully recorded. One series of blanks will cover information obtained at the mill during the process of manufacture. A second series will relate to rail statistics to be prepared by division officers, including a complete record of rail failures in main track. A third series will provide for statistical compilations of rail failures. A final series is to provide reports of actual measurements of

rail sections laid in the track at stated periods, in order to determine the relative wear of rails of different composition and manufacture.

The committee considered very carefully the advisability of changing the weights of the rail sections from those which have been standard on the system. It had been suggested that the increasing severity of service would probably call for the use of a rail of greater weight per yard. The committee concluded, however, that the sections should continue to be of the same weights as those already in use, although a change of radical character was made in proportioning the metal to the different parts of the rail.

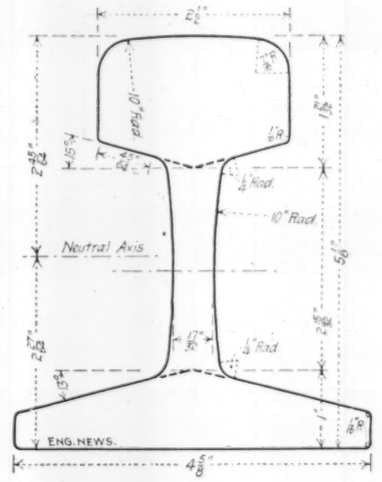

Fig. 1. Standard 85-lb. Rail Section; Pennsylvania R. R.

Prepared by Committee on Steel Rails.

Area of Head	3.57 sq. ins.	42.2%
" " Web	1.51 " "	17.8
" " Base	3.39 " "	40.0
Total	8.47 " "	100.0%
Moment of Inertia		29.1
Section Modulus	Head	10.77
" "	Base	12.02
Ratio Periphery Head to Area	Head	1.73
" " Web " "	Web	3.81
" " Base " "	Base	2.69
" Total Periphery to Total Area		2.48

CHEMICAL COMPOSITION.

1. The steel of which the rails are rolled shall conform to the following limits in chemical composition:

Bessemer steel rails:	Lower limit. %	Desired composition. %	Upper limit. %
Carbon	0.45	0.50	0.55
Manganese	0.80	1.00	1.20
Silicon	0.05	0.12	0.20
Phosphorus	....	....	0.10
Open hearth steel rails:			
Carbon	0.70	0.75	0.80
Silicon	0.05	0.12	0.20
Manganese	....	....	0.80
Phosphorus	....	....	0.03

PROCESS OF MANUFACTURE.

2. Ingots shall be kept in a vertical position until ready to be rolled, or until the metal in the interior has had time to solidify.

3. No "bled" ingots shall be used.

("Bled ingot"—One from the center of which the liquid steel has been permitted to escape.)

4. There shall be sheared from the end of the bloom formed from the top of the ingot sufficient discard to insure sound rails.

(All metal from the top of the ingot, whether cut from bloom or rail, is the top discard.)

5. In reheating, care shall be taken to avoid burning the steel, and under no circumstances shall a "cinder heat" be used.

("Cinder heat"—One in which the scale on the sides of the ingot becomes fluid.)

6. The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws, for a rail 33 ft. in length, of 6¼ ins. for 85-lb. section, and 6½ ins. for 100-lb. section. These allowances to be decreased at the rate of $^1/_{100}$-in. for each second of time elapsed between the rail leaving the finishing rolls and being sawed. The bars shall not be held for the purpose of reducing their temperature, nor shall any artificial means of cooling them be used between the leading and finishing passes, nor after they leave the finishing pass.

MECHANICAL REQUIREMENTS.

7. The name of the maker, the weight and type of the rail, and the month and year of manufacture shall be rolled in raised letters and figures on the side of the web, and the number of the heat shall be plainly stamped on each rail where it will not subsequently be covered by the splice bars. A letter shall be stamped on the web to indicate the portion of the ingot from which the rail was rolled.

8. The section of rail shall conform as accurately as possible to the templet furnished by the railroad company. A variation in height of $^1/_{64}$-in. less or $^1/_{32}$-in. greater than the specified height, and $^1/_{16}$-in. in width of flange, will be permitted; but no variations shall be allowed in the dimensions affecting the fit of the splice bars.

9. The weight of the rails specified in the order shall be maintained as nearly as possible, after complying with the preceding paragraph. A variation of ½ of 1% from the calculated weight of section, as applied to an entire order, will be allowed.

10. The standard length of rails, at a temperature of 60° F., shall be 33 ft. Ten per cent. of the entire order will be accepted in shorter lengths, varying as follows: 30 ft., 27½ ft., and 25 ft.; and all No. 1 rails less than 33 ft. long shall be painted green on ends. A variation of ¼-in. in length from that specified will be allowed.

11. The rails must be free from injurious mechanical defects and flaws; shall be sawed square at the ends, a variation of not more than $^1/_{32}$-in. being allowed; and burrs shall be carefully removed.

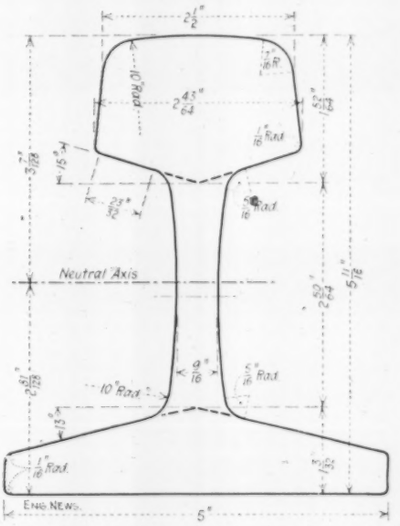

Fig. 2. Standard 100-lb. Rail Section; Pennsylvania R. R.

Prepared by Committee on Steel Rails.

Area of Head	4.09 sq. ins.	41.0%
" " Web	1.85 " "	18.8
" " Base	4.03 " "	40.4
Total	9.97 " "	100.0%
Moment of Inertia		41.9
Section Modulus	Head	13.71
" "	Base	15.91
Ratio Periphery Head to Area	Head	1.59
" " Web " "	Web	3.58
" " Base " "	Base	2.43
" Total Periphery to Total Area		2.30

12. The rails shall be smooth on the heads, straight in line and surface, and without any twists, waves, or kinks; particular attention being given to having the ends without kinks or drop.

The hot straightening shall be carefully done, so that gagging under the cold presses will be reduced to a minimum. Any rail coming to the straightening presses showing any sharp kinks or greater camber than that indicated by a middle ordinate of 4 ins. in 33 ft. will be at once marked as a No. 2 rail, and only accepted as such. The distance between the supports of rails in the straightening presses shall not be less than 42 ins.

13. Circular holes for splice bars shall be drilled to conform accurately in every respect to the drawing and dimensions furnished by the railroad company, and must be free from burrs.

TESTS AND INSPECTION.

14. One drop test shall be made on a piece of rail not less than 4 ft. and not more than 6 ft. long, selected by the inspector from each heat of steel, from any position in the ingot.

The test piece shall be placed head upwards on solid supports, 5 ins. radius, 3 ft. between centers, and both 85-lb. and 100-lb. sections shall be subjected to an impact test from a weight of 2,000 lbs. falling 15 ft.

The deflection for No. 1 classification rails must not exceed that indicated by a middle ordinate of 2 ins. in 3 ft. for 100-lb. section, and 2¼ ins. for 85-lb. section.

Test pieces shall be tested to destruction.

The temperature of the test pieces shall be between 60 and 120° F.

(a) If a test piece breaks without showing physical defect, all rails made from that heat shall be rejected absolutely.

(b) If, however, the test piece broken under test "a" shows physical defect, the top rail from each ingot of that heat shall be rejected; and

(c) A second test shall then be made of a test piece selected by the inspector. If this second test piece breaks, the remainder of the rails of the heat shall also be rejected. If this second piece does not break, the remainder of the rails of the heat will be accepted as either No. 1 or No. 2 classification, according as the deflection is less or more, respectively, than the prescribed limit.

(d) If the test piece, test "a," does not break, but when tested to destruction shows pipe, the top rail from each ingot shall be rejected. The remainder of the rails of the heat will be accepted as either No. 1 or No. 2 classification, according as the deflection is less or more, respectively, than the prescribed limit.

(e) If the test piece, test "a," does not break, and when tested to destruction does not show pipe, the rails of the heat will be accepted as either No. 1 or No. 2 classification, according as the deflection under test "a" is less or more, respectively, than the prescribed limit.

Note—The drop test and the deflection requirements may be modified if considered advisable by the railroad company.

15. The drop-testing machine shall have a tup of 2,000 lbs. weight, the striking face of which shall have a radius of not more than 5 ins. The anvil block of the drop-testing machine shall weigh at least 20,000 lbs., and the supports shall be part of, or firmly secured to, the anvil. The foundations for the anvil block shall be such as will meet the approval of the railroad company.

16. No rails shall be accepted which contain any physical defects that impair their strength.

17. Rails improperly drilled or straightened, or from which the burrs have not been properly removed, shall be rejected, but may be accepted after being properly finished.

18. No. 2 rails to the extent of 5% of the whole order will be received. All rails accepted as No. 2 rails must have the ends painted white, and must be kept separate from No. 1 rails, and be shipped in separate cars.

19. Rails will be accepted and billed according to actual weights.

20. All rails must be loaded in the presence of the inspector.

21. The makers shall furnish the inspectors with the carbon determination of each heat, and, also, two complete analyses which shall represent the average steel of each day's work, before the rails are shipped. These analyses will be checked from time to time by the railroad company's chemist, and, on request of the inspector, the makers shall furnish a portion of the test ingot for check analyses.

22. Inspectors representing the railroad company shall have free entry to the works of the makers at all times when the contract is being filled, and shall have reasonable facilities afforded them by the makers to satisfy them that the finished material is furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment.

THE HAUSER LAKE STEEL DAM was wrecked by the floods on the Missouri River on April 14. This structure, which was described and illustrated in our issue of Nov. 14, 1907, p. 507, is of steel framework covered with sheet steel, and serves to impound, across a 500-ft. opening, the waters of the Missouri River into a lake of 20 sq. mi., developing a horsepower of 25,000 for use in the mining and electrical operations in Helena, Butte and Anaconda. No authentic accounts of the cause or extent of the accident are available as we go to press.

TEN MINERS WERE KILLED in the Norton Hill Colliery, Somersetshire, England, on April 10, it is reported, as the result of a gas explosion. The first rescue parties were overcome by gases and were themselves saved only after great effort.

IN A FREIGHT LOCOMOTIVE EXPLOSION on April 9, near Derby, Conn., on the New York, New Haven & Hartford R. R., three trainmen were injured. The locomotive was reported as completely demolished, the three forward cars wrecked and the roadbed torn up. It is not known from what cause the accident resulted, although it is stated that the fireman had just fixed his fire to make additional steam for a heavy grade.

ANOTHER RECORD FOR FLIGHT on aeroplanes was recently established by Mr. Leon de la Grange, of Paris, who was aloft for 555 seconds. However, his wheels touched the ground at intervals so that he was above touching distance of the earth for 390 seconds, in which he covered about 2½ miles.

THE BERGEN HILL TUNNEL OF THE PENNSYLvania R. R., which is the westerly prolongation of the Hudson River tunnel by which the railroad will cross from New Jersey to its new terminal station in New York City, was holed through on the morning of April 11. The tunnel comprises two single-track rock tunnels, and it is the southerly one in which the headings met. The north tunnel is still some distance from junction. The tunnel was begun about the same time as the subaqueous tunnels, and was attacked from both ends, the west portal being at the edge of the Hackensack meadows, while the east heading was driven from the Weehawken Shaft (see Eng. News, Dec. 13, 1906), a shaft sunk near the shore of the Hudson River to serve jointly the shield-driven subaqueous work and the Bergen Hill work. The distance from Hackensack Portal to Weehawken Shaft is 5,910 ft.

A $6,000,000-FIRE destroyed about a third of the entire city of Chelsea, Mass., a suburb of Boston, on April 12. The fire started about noon in a rag and junk shop on the extreme western part of the city and the burning sparks soon were blown to a blacking factory in whose stores of oil and resin it obtained a quick start. The 60-mile gale that was blowing made it impossible to confine the fire and it was rapidly swept eastward, spreading to the north and south. The first buildings in the path of the fire were largely wooden tenements by which the fire was fed so that brick and stone buildings in the business section were no obstacles. The destruction continued into the better residential section and down to the water front. At the last point were the tank yards of the Tidewater Oil Co., and of Leonard & Ellis. In spite of all that could be done the fire was carried across Chelsea Creek into the yards of the Standard Oil Co. East Boston now became threatened, and it was only by manning all possible apparatus at this point that the flames were kept inside the grounds of the Standard Oil Co. The conflagration was checked on the north at the tracks

of the Boston & Maine R. R. and did not cross them until nearly down to the water front. Assistance in fighting the fire was given by all the neighboring places; the state militia was called out and all available marines and sailors at the Charlestown Navy Yard were pressed into service in placing the city under martial law. It is reported that only six persons were killed, although about fifty were injured, about as many more are missing, and ten thousand are homeless. Relief work was instituted before the fire was under control; food, tents and blankets were hurried in and public buildings in neighboring suburban cities were thrown open for shelter. It is expected that $100,000 will be appropriated by the Commonwealth of Massachusetts for the relief fund and as much more is expected from other sources in the state.

THE EVANSTON BRANCH OF THE CHICAGO Drainage Canal was put under construction on April 3, beginning at the lake shore in Wilmette, a half-mile north of the Evanston boundary. From this point a branch canal will extend through the northwestern portion of Evanston, southwardly to a junction with the north branch of the Chicago River. The surface of the waterway will be 100 ft. in width, thus leaving a 250-ft. margin on each side. It is stated that within the Evanston city limits these margins will be available for parkways. It is also stated that the excavated material will be used to form an island of some 20 acres or more, and that Wilmette has organized a park district for the utilization of this island and for improving the banks of the canal.

FIRE DESTROYED THE WATER-WORKS PUMPING station of Newport, Ky., on the night of April 12. Reports indicate that owing to lack of apparatus at the station and the inaccessibility of the station nothing could be done to stay the flames. A temporary supply of water is being secured from the water-works of Covington, Ky. The burned station was on the Ohio River, opposite the new pumping station and filtration plant of the Cincinnati water-works.

DYNAMITE BOMBS DESTROYED STRUCTURAL steel, on April 13, intended for the Delaware Ave. elevated railroad line in Philadelphia. Two bombs with time fuses had evidestly been carefully placed under two piles of girders in the old navy yard at the foot of Wharton St. Several derricks for handling the steel were also demolished. It is thought that the bombs were placed by dissatisfied workmen of the American Bridge Co., which owned the material.

A TRAIN WAS DITCHED on the Northern Pacific R. R. near Glendive, Mont., April 14, by running onto a burned bridge. The fireman and a tramp were killed.

PROGRESS IN THE LOETSCHBERG TUNNEL in February, 1908, was as follows: North heading, 525 ft.; south heading, 397 ft. The total length of headings at the end of February was 5,743 ft. and 5,137 ft., respectively, a total of 10,880 ft. The mean temperatures at face of heading were 54° F. at the north end and 69° F. at the south end.

A STOPE DRILL COMPETITION has been arranged for by the Transvaal government in cooperation with the Transvaal Chamber of Mines through a series of practical trials of small rock drills suitable for narrow stoping work under the conditions at the Witwatersrand. The competition will open early in 1909 and entries will close late in 1908. The trials will last about six months, the drills being tested in the first instance on the surface and those considered suitable being given a more prolonged test underground in several stopes in various mines. All types of rock drills are eligible to compete. Drills using compressed air will be supplied with a pressure varying from 60 to 75 lbs. per sq. in. at the working face. The mining regulations require the provision of dust-allaying appliances and competitors must make provision accordingly. Two prizes, of $20,000 and $5,000, respectively, are offered. The trials and the judging will be so arranged as to decide which machine performs the most economical work. Inquiries should be addressed to The Secretary, Stope Drill Competition, Transvaal Chamber of Mines, Johannesburg, Transvaal; or to The London Secretary, Transvaal Chamber of Mines, 206 Salisbury House, Finsbury Circus, London, E. C.

THE RICKEN TUNNEL HEADINGS MET on March 30, according to press dispatches. This tunnel is in the Canton St. Gallen, in northeastern Switzerland, and extends from Uznach to Wattwyl. It shortens the north-south railway routes in eastern Switzerland, though if either the Splügen or the Greina tunnel projects goes through, the Ricken will serve mainly local needs. It is 28,221 ft. long between portals. It was begun about the end of 1903, and progressed steadily, with occasional trouble from firedamp but without excessive difficulty, until March, 1907, when, the headings being 93% through, a very strong flow of firedamp was tapped in both north and south heading. The gas, which took fire, stopped all work for some months, but in July the full-section enlargement and lining operations were resumed, with the use of safety lamps. In October the fire was out and the flow of gas small; the temperature having gone down, work was resumed at the south heading, with safety lamps, and since then the progress of this heading has been fairly rapid. The advance in January, 1908, was 387 ft., in February 407 ft., and at the end of February the headings were only 531 ft. apart. It seems that this distance has been pierced in one day less than the full month of March, but possibly some work was done in the north heading. An important feature of the work in the headings was the exclusive use of hand drilling.

STATIONARY BAR PHOTOMETERS FOR GAS TESTing were in use by 31 companies supplying gas in the State of New York, outside of the city of New York, at the close of 1907, according to the report of the Public Service Commission for the Second District of New York. An order requiring all companies manufacturing and distributing more than 15,000,000 cu. ft. of gas per year to install such photometers before Sept. 1, 1907, was promulgated by the Commission of Gas and Electricity, one of the predecessors of the Public Service Commission. A total of 57 companies were affected by the order, of which 24 already had such photometers.

HOT ARTESIAN WATER is reported as having been struck at Edgemont, S. Dak., at a depth of 3,000 ft. A well was being sunk by the Chicago, Burlington & Quincy R. R., when the hot-water vein was struck. A heavy yield is reported.

PERSONALS.

Mr. Echols McBee, Assistant Engineer of the Seaboard Air Line, has resigned that position after nine years' service and will enter business in Birmingham, Ala., as an engineer and general contractor.

Major William E. Craighill, Corps of Engineers, U. S. A., who has been Engineer of The Seventh and Eighth Light-House Districts, under the direction of the Secretary of Commerce and Labor, has been ordered to Baltimore, Md., to relieve Col. Richard L. Hoxie, M. Am. Soc. C. E., in charge of the fortification and river and harbor works about Baltimore.

Mr. E. E. Keller, M. Am. Soc. M. E., for over 20 years connected with the Westinghouse interests and for 14 years Vice-President of The Westinghouse Machine Co., having completed his duties as Receiver and General Manager, severed his connection with the management of that company on the first of this month. After a vacation he will devote his time to personal interests.

Dr. Samuel Walker Beyer, M. Am. Inst. M. E., for many years head of the School of Mines of Iowa State College, has been elected Dean of The School of Mines and Metallurgy of Pennsylvania State College. He received the degree of B. S. at Iowa State College in 1889 and that of Ph. D. at Johns Hopkins University in 1895. He is connected with the Iowa Geological Survey and is Assistant Geologist on the U. S. Geological Survey. He has been a frequent contributor to scientific publications on the mineral and mining resources and industries of the Middle West. When he becomes Dean of the Pennsylvania School of Mines its organization will be expanded into four departments: mining, metallurgy, geology and ceramics.

Mr. Harrison P. Eddy, M. Am. Soc. C. E., of Metcalf & Eddy, Consulting Engineers, 14 Beacon St., Boston, Mass., has declined the position of head of the Street Department of Boston. This department, in accordance with a recent city ordinance, is to be reorganized to combine practically all of the city departments having street work in hand, outside of the Water Department. The new head of the department will receive a salary of $7,500 a year. Within a year past, Mr. Eddy resigned the position of Superintendent of Sewers of Worcester, Mass., which he had held for many years. This he did in order that he might enter into consulting work. He states in his letter of declination that he still holds to his purpose to continue his practice as a consulting engineer.

Obituary.

Lester A. Pelton, the inventor of the Pelton water-wheel, died on March 15, at Oakland, Cal., at the age of 78. He was born in Vermillion, Ohio, and came to California during the gold excitement of 1849. He built his first wheel there to develop power for mining work and lived to see the name of his invention become almost a generic term for all impulse wheels.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ASSOCIATION.
April 22. Semi-annual session at New York City. Secy., W. F. Allen, 24 Park Place, New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 30-May 2. Annual meeting at Albany, N. Y., Secy., Joseph W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN WATER-WORKS ASSOCIATION.
May 11-16. Annual meeting at Washington, D. C. Secy., John M. Diven, 14 George St., Charleston, S. C.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 19-22. Annual convention at Chicago. Secy., W. W. Freeman, 29 West 39th St., New York City.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 26-28. Annual meeting at Chicago. Secy., W. H. Merrill, Jr., 382 Ohio St., Chicago.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 9-11. Annual convention at Toronto, Ont. Secy., Richard Moldenke, Watchung, N. J.

MASTER CAR BUILDERS' ASSOCIATION.
June 17-19. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 22-24. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 23-26. Annual convention at Denver, Colo. Secy., C. W. Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 23-26. Annual convention at Detroit, Mich. Secy., C. W. Rice, 29 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 23-26. Annual meeting at Detroit, Mich. (In connection with convention of American Society of Mechanical Engineers.) Secy., A. L. Williston, Pratt Institute, Brooklyn, N. Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 23-27. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 29-July 2. Annual convention at Atlantic City, N. J. Secy., Ralph W. Pope, 33 West 39th St., N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—At the regular meeting, held at the Engineers' Building, 29 West 39th St., New York City, on April 10, Mr. Henry Floy presented a paper on "The Engineer's Activity in Public Affairs—Public Utility Commissions and Franchise Evaluations." Mr. Floy mildly attacked the present constitution of public service commissions and advocated having a considerable representation of engineers on all such boards. In discussing present ways of evaluating franchises, Mr. Floy stated that if 6% was a legal rate of interest and if a capitalist would accept 8% on actual cash investments in such public service concerns then it would prove equitable and desirable that the valuation and capitalization of the franchise should make this possible. This would mean that the franchise valuation would be one-third the actual investment.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The April meeting was held in the main auditorium of the Engineering Societies' Building on the evening of April 14. The general subject was "The Conservation of Our Natural Resources" and the speakers were Dr. W. J. McGee, Secretary of the Inland Waterways Commission; Dr. W. F. M. Goss, Dean of the College of Engineering of the University of Illinois; Prof. Geo. F. Swain, Director of the Department of Civil Engineering of the Massachusetts Institute of Technology, and Dr. Henry S. Pritchett, President of the Carnegie Foundation.

The meeting was largely attended by members of the civil, mining and electrical engineering societies. At the opening of the meeting Secretary Rice read the following letter from President Roosevelt:

The White House, Washington, April 13, 1908.

My dear Mr. Rice:

I regret that time did not permit me when you were here to tell you how gratified I am with the zeal and interest which the members of the engineering profession are taking in the movement to conserve our natural resources.

It is the duty of all our citizens to exercise foresight in these matters, but it is peculiarly the duty of the engineer, who is in fact a trustee of the forces of nature. Above all men the engineer is responsible for seeing that our natural resources are not wasted and that their development is for the common good and for the continuance of the welfare of our citizens.

I was particularly pleased with the resolutions passed by your Council and indeed with the cooperation of all engineering bodies in bringing this matter forcibly to the attention of all the people. I am sorry that I cannot be with you on Tuesday evening to hear the addresses, but I extend to all the engineers my heartiest good wishes.

Sincerely yours,
Theodore Roosevelt.

Dr. Goss, in speaking of the conservation of the fuel resources, called attention to the enormous increase in fuel consumption, and urged attention to economies in its use. Nearly one-fourth the coal used in the United States is burned by locomotives, and it has been well demonstrated that a large decrease in fuel consumption on locomotives is entirely practicable.

Prof. Swain directed attention to the importance of forest preservation and restoration on the mountain slopes to protect the soil from erosion and increase the flow in rivers during periods of drought.

Dr. Pritchett emphasized the duty which the engineer as a professional man owes to the public, for the general welfare of society.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. 220 Broadway, New York, April 16, 1908.

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SPECIAL.

The Making of Literature for Engineers.*

By CHARLES WHITING BAKER, M. Am. Soc. M. E.

Of making many books there is no end, and much study is a weariness of the flesh!

So wrote a wise man, over 2,000 years ago; many centuries before the art of printing was dreamed of; when books were parchment rolls or papyrus leaves; when there were no libraries, Carnegie or otherwise; when the district school and the college and the newspaper and the magazine and a thousand other integral features of our civilization were all hidden in the mists of futurity.

This text has always had a certain fascination for me. I presume you in this audience appreciate particularly the assurance concerning the certain result of much study; but I have in mind the "many books" part. I have not written many books, but for the past 21 years I have had a responsible part in the making of one very long book, of which, indeed, the end is not yet in sight. During that time the yearly volumes of the journal of which I am editor have accumulated until they occupy some seven feet of shelf room; and they are rather portly. Taking a fair average for the number of pages in a volume and the number of words on a page, I suppose that there must be in those 42 volumes of Engineering News perhaps 25,000 pages of reading matter and, say, 75 million words.

And I am only one sinner among many of these makers of books!

In talking to you to-night about the making of engineering literature, this is the first thought that I want to strongly impress upon you. That the *voluminosity* of engineering literature—the "many books," as Ecclesiastes put it—constitutes a real, serious problem at the present day.

I say, "at the present day," because this problem is quite a new one. Most engineers have not even awakened to the fact that it is a problem at all.

We do not have to go back further than the memory of engineers still in active practice to reach a time when engineering literature was almost non-existent, and what little there was available was exceedingly poor stuff. If you want to verify this, go into your college library and hunt up an engineering treatise published prior to 1850, or 1860, or even 1870; and see what kind of knowledge of his profession it was then possible for an engineer to obtain from books.

A former colleague of mine has often told me of an experience of his along this line. In his early professional life, nearly forty years ago, he tried to accumulate a small professional library and he bought among others an engineering treatise by an English writer quite well known in his day. When my friend came to study the book, he was greatly puzzled over the figures and tables in it. He finally discovered that all the numerical matter was written in duodecimals. It seems that the duodecimal system was a particular hobby of this writer, and so he adopted it for his books, regardless of the fact that by so doing he practically destroyed their usefulness.

It is not strange that when such books as this were ranked as professional literature, practicing engineers had small respect for "book knowledge" and the public closely reflected their opinion. Something of this feeling survives even down to the present day. There is a feeling that the information gained from books—or from the printed page—is inferior and unreliable compared with the information gained by word of mouth. There is an idea that books have to do solely with abstract theory; and that practical knowledge—the sort of knowledge to guide a man in his professional work—cannot be gained from publications.

That there is some reason for such prejudice, I shall not attempt to deny; but I hold that the real reason is the carelessness and incompetence of authors, and editors and publishers. We allow too much that is false and misleading and incomplete to be perpetrated in cold type. So far as engineering literature is distrusted, it is because it has not been made sound enough and reliable enough to be worthy of trust.

But I am wandering from my text. The point I want to bring forcibly to your attention is that whereas 40 years ago engineering literature was almost non-existent, to-day it is heaped upon us in overwhelming floods. There are to-day several hundred weekly and monthly publications, devoted to engineering and its various branches, which are carried on by private enterprise. Besides all these journals, there are some hundreds of engineering societies of all grades, from the great national organizations to the local societies in the engineering colleges; and a very large proportion of these societies publish proceedings containing the papers and discussions at their meetings. Added to this is the avalanche of new books on engineering subjects which ambitious authors and venturesome publishers are all the time pouring forth.

Remember, too, that all this refers to the English language alone. There is, besides, a very voluminous engineering literature in German, a considerable amount in French and a small amount in Spanish, Swedish, Italian and a few other languages.

In looking at this huge bulk of literature, I am minded to compare it with the great international expositions, which have become something of a public craze in recent years. You know how the promoters of these great expositions have attempted to make each one bigger than its predecessor—to have more acres of grounds, larger exhibition buildings, a vaster array of exhibits. Entirely overlooked is the fact that human endurance is strictly limited, and that the human mind can absorb a certain amount of knowledge in a given time and no more.

So with the vast mass of our present day engineering literature. No one can read it all—no, not even the tenth part of it—even were he to do absolutely nothing else. When we contemplate it in the mass, so to speak, one is tempted to ask whether it is worth while; whether, on the whole, the time and money and energy spent in its production is well spent.

ENGINEERING LITERATURE A NECESSITY TO THE ENGINEER.

The best answer I can make to that question is to say that if it were not worth while, engineers would not pay out their hard-earned money to buy it. The fact is, that with the development of engineering the profession has been compelled to rely more and more upon its literature. We shall not be far wrong if we speak of professional literature as a necessary tool in the engineer's workshop.

Take any one branch of engineering; let us say, for example, water-power development. We do not have to go back more than 40 years to reach the time when the old "millwrights" were the men who actually did all the work that was done in this country in the development of water-power. All the knowledge they needed was carried under their hats, with perhaps some few rules copied in a private note-book. To-day, however, an engineer who conducts a water-power development enterprise must, either directly or through assistants, be familiar with the latest practice in stream gaging, dam construction, hydraulic motors and regulators, electric generation, transmission and utilization, and power-house construction, to say nothing of such matters as the relation between engineers and contractors, executive methods, dealings with labor organizations, franchises, and riparian rights. It may be well, also, for him to know how to handle a board of directors and float a bond issue.

Perhaps you may object that no one engineer can do all this, but the fact is that engineers in the aggregate *are* doing all these things; and that every successful engineer to-day finds himself constantly in need of knowledge that he cannot carry in his head and for which he must rely on the experience of others, as recorded in professional literature.

Engineering literature, then, is a necessity to the engineer of to-day. He is confronted with a vast mass of books and journals and his problem is how to dig out of them the things which he wants and needs. The problem of the makers of engineering literature is how to turn out their product in usable form. How to give the engineer what he needs and give it to him in such shape that he can take it and apply it.

SPECIALIZATION IN ENGINEERING LITERATURE.

The solution of this problem lies in two directions: first, specialization; second, condensation.

The specialization of the engineering profession is a thing more recent than we are apt to realize. Less than a century ago, it may be said that practically the only engineering work done was the construction of canals. The formal differentiation of the profession into four great main branches of civil, mechanical, mining and electrical has taken place within a quarter of a century. To-day each of these great divisions is specializing into a dozen or twenty subdivisions, and to quite an extent each of these subdivisions has its own special literature.

This specialization, you may say, solves our difficulties. An engineer does not have to read the whole vast mass of the literature of his profession, but only that relating to his own specialty. Actually, however, the problem does not work out so easily. There are no tight fences built between the different specialties. On the contrary, the boundaries overlap on every side. Here is your engineer, let us say, of a Portland cement works, interested in the uses of cement in bridges, buildings, dams, conduits and a hundred other structures, and also in the appliances of the mine and quarry, in steam-shovels, kilns, hoisting and conveying machinery, in steam and water-power machinery and in the conveying of materials. Manifestly, then, this engineer wants something besides the literature of Portland cement manufacture.

There is another reason why an engineer cannot wisely make his reading of too limited scope. Very few engineers stay long in one position. In all construction work the engineer is constantly working himself out of a job. Nothing is more common than for an engineer to take up an entirely new line of work. Many engineers do this deliberately, for the sake of broadening their experience. You will readily understand, therefore, why we cannot solve the problems of a too-voluminous engineering literature simply

*An address delivered March 27, 1908, before the engineering students of the University of Michigan.

by saying that each engineer shall read the literature of his own special branch. If he is wise and ambitious he will read that and much more.

Now let us turn to our second specific: condensation. What measures can we take to reduce the volume of professional literature, or rather, since that may be too ambitious a program to bring to pass, what sort of engineering literature will you write in order that it may be read and valued, and what kind will you read in order that you may use your time to the best advantage?

THE STANDARD OF EXCELLENCE IN ENGINEERING LITERATURE.

But before we answer that question, perhaps we ought to tackle another and more fundamental one. The question, what *is* engineering literature, or better yet, what is its purpose; what standard shall we judge it by?

This is a very practical every-day question with me. There come pouring in upon us from all parts of the world manuscripts, papers, discussions on a vast variety of engineering topics. All these must be critically examined and sifted. The standard which we have fixed upon as our guide, by which to make our selection, is a very simple one. We give first place to the contributions which promise to be *the most helpful to the working engineer*. The papers which best deserve the distinction of printing are those which tell something that helps the man in the field, or the shop, or the office. The books of widest circulation among engineers are those which are most practical.

It may seem to you that this standard is so simple and so self-evident that it ought to be obvious to any one; but actually it is very far from universal acceptance.

Curiously enough, the standard which some people set up is quite the opposite. There is a very considerable body of engineering literature which assumes to itself an air of superiority because of the fact that it is of no use whatever. What I am referring to is the sort of theoretical discussions and records of experimental research which wander so far away from the practical worker that he can never make any use of the results.

When you make a critical analysis of engineering literature, measuring it all by the standard I have just stated, you will be surprised to find what a large proportion of the space in these engineering journals and society transactions is taken up with matter which nobody ever used and nobody ever will use.

Our British cousins are particularly hardened sinners along this line. The idea still has tenacious hold over there that the thing which is directly useful has a plebeian odor about it, while useless knowledge has something of the same odor of sanctity that clings around the old classical studies. So, in the attempt to apply science to industry, they have set theory up on a pedestal; and they have a mania for carrying on elaborate researches to find out facts which, when they are found out, are of no earthly consequence.

In saying all this, don't think for a minute that I am condemning theory in its proper place, aimed square at a practical result, or against research with a like aim.

What I condemn is this vague theorizing and experimenting, with nothing more than a hazy possibility that somebody, sometime, somewhere, may find it useful. Why cumber our crowded engineering literature with this stuff, when we need the space for things so much more important?

Do not understand, either, that I am saying anything against real scientific research, worthy of the name, aimed at an intelligent and well planned end. What I am inveighing against is that pseudo-scientific research which takes, let us say, a particular machine, puts it under a dozen mathematical microscopes, pulls it to pieces in chemical and physical laboratories, and yet with all this elaborate investigation reaches no useful end.

From this misdirected energy may the engineering literature of the future be delivered!

There is another sort of engineering literature which at the present day we ought to scrutinize very carefully, and that is descriptions of engineering works. It may seem strange to you—the idea that descriptions of engineering work should not have the first place in engineering literature. There was a time, not so many years ago, when engineering journals consisted almost wholly of such descriptions. But suppose to-day we were to attempt to publish descriptions of every engineering work—of every good-sized bridge and water-works and steam-engine and mine and power station, and so on throughout the whole range of activity of a hundred thousand busy engineers. You can easily imagine in what a swamp of engineering literature the profession would land.

Evidently, then, we have got to draw the line somewhere. I have to draw this line daily and hourly. When contributors assail me, as they do all the time, with the question whether we want a description of this or that or the other engineering work, I, Yankee-like, answer their question by asking another. What is there about your engineering work that makes it worth the attention of the profession? What features of novelty has it, that your brother engineers want to know about?

Of course, our professional literature must have descriptions of the great record-breaking works. An engineer must know something of the latest achievements of the profession in ocean navigation, in submarine tunneling, in high buildings, great bridges, and a hundred other directions in which the engineer is performing new and wondrous feats. Our technical journals also ought to contain accounts of the new and meritorious departures in all branches of engineering work.

And if we do these two things thoroughly, we shall have no space left for vain repetition in descriptions of the ordinary works.

And now I think I hear a complaint coming from the man who isn't familiar with these ordinary works. He wants to know how they are put together. Very few engineers ever get a chance to build record-breaking skyscrapers; while many thousand are interested in the details of ordinary buildings. Certainly, therefore, descriptions of *typical* works of ordinary size are useful to the reader and deserve a place in our publications.

THE ETHICAL STANDARDS OF ENGINEERING JOURNALISM.

I have said that we must make helpfulness to the working engineer the standard by which to judge of engineering literature. I would like to give you a little idea of what it means to set up this standard. The editors of technical and trade journals are all the time bombarded with appeals to publish something to help this interest or that advertiser, or the other good fellow. It seems so easy to the man on the other side of the fence for the editor to let in just this one little puff. But the editor knows that if he does it for Brown to-day, he will be assailed to-morrow by Jones and Robinson to do the same thing for them; and the day after, forty more surnames will be knocking at his door.

I am glad to tell you that in my 21 years' experience in engineering journalism there has been a great improvement in its ethical standards. All reputable professional journals to-day place the selection of matter squarely on the basis of interest to the readers. That this basis is the only sound one is recognized not only by the technical side of the profession, but also by the commercial side. Engineering journalism receives the bulk of its financial support from advertising patronage. All the principal industrial advertisers freely recognize that the journals which select matter solely in the readers' interest will have the widest circulation and largest influence, and are consequently the most profitable for advertisers to patronize.

And now I want to bring before you an idea which will be new, I am sure, to the great majority of engineers. I have showed you how the engineering profession is suffering from the too great bulk of its literature. I have explained that editors and publishers of serious professional journals have set up the high standard of helpfulness and value to the reader as their guide in the selection of matter.

Why ought not the profession itself set up the same high standard for its guidance? If we editors select matter for the benefit of the profession, why should not the writers write papers for the benefit of the profession? Is it not of the very essence of professional standards for the individual to place the benefit to the profession at large ahead of his own personal benefit?

This is what we can all see ought to be; but the actual reality is that self-advancement is the motive which causes the production of most of the articles in our engineering publications. An engineer completes a piece of work and says to himself, "Now, if I write an elaborate description of this work it will add to my professional reputation." Really the question he ought to ask is this: "Is there anything in this work I have done that my brother engineers—perhaps my business rivals—would find it useful to know about?" When he solves a difficult problem does he say: "I ought to publish the solution of that problem to help some other fellows who may also have to struggle with it?"

That is the standard which I want to see followed more and more by the engineers who create engineering literature; and I am glad to tell you that already a very considerable number of engineers are adopting that high professional standard.

The adoption of this standard will do more than anything else to solve our difficulties with the superabundance of our literature and on the other hand to make accessible a great amount of valuable and useful information that is now being selfishly hoarded by private interests.

ENGINEERING LITERATURE SHOULD BE WRITTEN BY ENGINEERS.

You will see that a first essential to the standard I have described above is that engineering literature should be made by engineers. A great deal of our present-day publications is written by people who are not engineers at all. There are a considerable number of men, perhaps thirty or forty in all in the United States, whose names are known to all editors of technical journals. These men are, for the most part, men with some newspaper experience, who have taken up the special business of gathering information about new things in the industrial world and selling it to the various journals. We measure the contributions offered by this class of people by the same rule that I have described to you; and I am obliged to say that in about ninety-nine cases out of a hundred they fall short.

The fact is, that nobody but an engineer is competent to appreciate the technical information which other engineers will find of practical value. It is really as absurd to have newspaper reporters writing technical articles for the instruction of engineers as it would be to set them writing papers for the medical journals.

There is another reason why the conscientious editor has to be very careful about accepting contributions from these literary hacks. I have told you that we make helpfulness to the engineer the standard in selecting matter for publication; and I should like you to reflect upon the sort of omniscience which this demands on the part of the editors.

The number of contributions offered for publication in Engineering News now amounts to about 1,500 per year. We have to examine each of these and ask: is this work novel? Not necessarily is it absolutely new in the sense that the Patent Office requires, but will it be new to the great majority of readers? In the second place, we must ask: is it meritorious? Is this new machine an advance over previous machines in general use? Is this new way of mixing concrete, or applying air brakes to a train, or operating a photometer, or figuring a long column, better than the ordinary way?—enough better to bother the busy engineer to tell him about it?

Now, editors are neither omniscient nor infallible. What they do is to do the best their limitations permit. However, by combining the knowledge of all the different members of the staff, each covering a different specialty, they

are able to judge pretty fairly, as a rule, of the merits of an offered contribution. But in all cases our decision is influenced—and properly influenced—by the reputation and professional standing of the author. You have heard the old complaint of ambitious young writers for the popular magazines, that the editors do not judge by actual literary merit but by the writer's reputation. The editors of professional literature, however, *must* take the writer's reputation into account. Here, for example, is a paper on a new method of constructing a breakwater, giving various facts and figures concerning it. If this comes from some newspaper writer, I know by sad experience that I cannot be certain of any statement in it. How can I be justified in printing it, thus placing these statements where they may cause some engineer, who relies upon their accuracy, to make a serious blunder?

On the other hand, suppose this same article comes to me from an engineer of reputation and experience who has been directly connected with the work. The facts and figures are backed by his name. He is writing about something which he knows all about. You can readily see, then, that the engineering editor must not only consider the matter offered to him but from whom it comes. You can see also that a wide acquaintance with engineers and their professional standing is one important duty of the engineering editor.

There is another rule which follows close after the rule that engineering literature should be written by engineers. It is that *the responsibility for every article should be clearly fixed.* Engineering literature is not written for amusement, to while away an idle hour. It is, as I have said, a necessary tool of the engineer's workshop; and every engineer must know how reliable and accurate his tools are. An engineer might well hesitate to base action on a stray paragraph in a newspaper, when the same statement, coming from a leader of the profession, might be the basis of important action.

It is a rule of long standing on my own journal that, so far as possible, every article must show who is responsible for the statements made. Articles not signed or otherwise credited are understood to be the work of the editorial staff; but, so far as possible, in all such articles credit is given for the source of the information.

THE REWARD FOR HIGH-CLASS CONTRIBUTIONS TO PROFESSIONAL LITERATURE.

Forty years ago the engineering profession in this country was a little family. Every engineer knew personally most of the other engineers and knew also whether each man was good, bad or indifferent. To-day engineers are a great army. No man can know well more than a few men in the circle of his immediate acquaintance. Engineers in high positions to-day find real difficulty in selecting men for responsible work on whom they can place full reliance.

The only way an engineer can make his abilities widely known to the profession to-day is through contributions to engineering literature. Do not jump to the conclusion, however, that by writing a few articles for the technical press you will be quickly landed on Easy Street. I must hark back to my text and remind you of the "Many books." It is not enough to write; neither is it enough to write well and get the editor to accept and print and pay for your article. If you are really in earnest in calling the attention of other engineers to your transcendent abilities, you must write something that will command attention.

Of course the matter must have first consideration. Don't write unless you have something to say of real importance. Engineering literature suffers occasionally from the productions of men who write because an editor asked them to. Men, because they actually have nothing to say, they fill up the vacancy with platitudes. We will suppose, however, that you really have something that is worth the profession's attention. I want to impress on you the idea that it is worth while taking pains with the *manner* of your presentation.

Suppose you were going to address an audience of 25,000 people. Would not you think it worth while to write and rewrite your address again and again, to go over it with most painstaking care, and study how to hold the attention of your audience?

And if the editor puts you on the stage in his pages to face an audience of 25,000 people, isn't it worth while to take similar pains?

Take my word for it, the professional journal offers to the engineer of real, marked ability a means of making that ability known to the profession, provided he will take the necessary pains to command the reader's attention.

But you ask, "How should one write for engineers?"

To answer that question I should have to give you a course in rhetoric; but you need not be alarmed; I shall not attempt to do it to-night. Of course, the rules for writing good engineering literature are practically identical with those of ordinary literature. I can, however, mention two or three rules that I have found helpful.

The first is that, in order to write well and clearly, you must be able to *put yourself in the reader's place.* You must keep clearly in mind his point of view as well as your own. The common mistake among technical writers is to assume that the reader knows more than he does. This is why much engineering literature is hard reading. This is why you read Mark Twain or play base-ball when you ought to be reading Engineering News. Don't make the opposite mistake, however, and cumber your article with tedious explanations of things with which the reader is perfectly familiar.

A second rule, more honored in the breach than the observance is: "Use words in their *exact* meaning." Daily and hourly, we editors have to change the phraseology of contributions because the writer chose words which actually failed to express his idea. Our English language is so rich in words closely similar yet with a shade of difference in the meaning that one has to be constantly on his guard against this error.

Again, don't think that engineering literature must be written in a style as dull and deadly as a door mat. I don't mean that you should lug in "fine writing," so called, where it is out of place; but there is ample opportunity in engineering literature to use all the graces of rhetoric. One man can write an article in a way to fascinate and hold the attention of the reader, where another man will write an article on the same subject, giving substantially the same information, and it will be as dry reading as the Patent Office Gazette.

HIGHER STANDARDS FOR THE ENGINEER'S WORK.

I have told you that the standard by which to judge engineering literature is its helpfulness to the practicing engineer. Now let me broaden this standard and say that engineering literature ought to represent the best thought and aspirations of the engineering profession.

Besides the day's work, must we not have something to interpret the meaning of the day's work? Ought there not to be room in our engineering journals for history, for biography, for those aspects of engineering that touch closely the largest problems with which the human race is to-day grappling?

Hitherto the public has employed engineers in order to make a dollar earn the most interest. We stand on the threshold of a new era when the engineering expert will be emp'oyed *because he cannot be dispensed with.* The increasing complexity of all art and industry demand trained experts for their guidance.

New problems in government, in economics, in sociology, force themselves to the front demanding solution; and that solution lies in the hands of the engineer. The State of Michigan, when it would take a forward step by making a valuation of the railways within its borders, placed the work in the hands of an engineer of eminence—your own Professor Cooley. When the United States and Canada found that the waterways bordering the two countries must be preserved from injury, they placed the great work in the hands of an International Commission of Engineers, among them your own Professor Williams.

These are but samples of the great responsibilities which the engineer is to be called upon to undertake. Surely our engineering literature must have something bearing on these momentous tasks.

And finally, I want to impress upon you that our profession must emphasize more and more the importance of high ethical standards. We must make the engineering profession synonymous with honor and honesty and high minded purpose.

To-day the public is in a quandary to know whom to trust. It distrusts the politician. It distrusts the financier. It distrusts the lawyer. If the engineering profession can upbuild its reputation as a body of experts, who hold fidelity to duty high above all private interest—if the public may trust the engineer, not alone because of his personal character, but because he has the added safeguard of loyalty to the standards of his profession—if these things shall come to pass (and believe me, they *are* coming to pass) then the people will turn to engineers as to no other body of men for safe conduct over the stormy oceans which the Ship of State must sail.

So, then, our professional literature must upbuild our professional standards. It must make not only wiser experts but safer counsellors. It is a task demanding the best thought and the best energy of the ablest men in the profession.

Rightly understood—rightly accomplished—the engineer may aspire to be the statesman of the future.

USEFUL INFORMATION FOR PRACTICAL MEN.—Compiled for E. I. du Point de Nemours Powder Co., Wilmington, Del. Leather; 4 × 6¾ ins.; pp. 216; illustrated. $1.

The editors of this handbook have made a very judicious selection of data and information largely from the many well-known handbooks, to whom proper credit is given. There are the usual general tables of physical data, of building materials, of boilers, pumps, hoisting engines, light locomotives, etc. The most important part, or at least the part which will appeal most to persons who find the volume useful, is a chapter on explosives—both "high" and "low." This matter, emanating directly from the largest powder makers in the country, should be authentic, and may be taken as showing well recommended practice. The many explosives made by this concern are listed and general directions for their handling is first inserted. After that the special precautions to secure best results are added. These are for rock, submarine, lumbering and general blasting. Special attention is given to an exposition of the proper methods of transportation, storage and thawing of high explosives. Black powder is not ignored in this chapter, but its field is outlined and its proper uses recounted where it is desirable to have the slower heaving explosion that is not attainable with dynamite.

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The Myron C. Clark Publishing Co.

357 Dearborn St., Chicago, Ill.

Railway Operation.

Reviewed by HENRY S. HAINES,* M. Am. Soc. C. E.

ECONOMICS OF RAILWAY OPERATION.—By M. L. Byers, Chief Engineer Maintenance-of-Way, Missouri Pacific Railway. New York: The Engineering News Publishing Co. London, England: Archibald Constable & Co., Ltd. Cloth; 6 × 9½ ins.; pp. 672; diagrams, folding tables and text illustrations. $5, net.

From time to time it is well to gather together the diversified experiences of those who have been instrumental in adding to the stock of information in any department of knowledge. It is the merit of works of this character that they render the experience of each laborer in that department available for all who are similarly employed; thereby preventing the useless expenditure of time and energy in the repeated solution of problems which have already been solved. This service becomes of especial value when it is undertaken in a field of activities closely associated with all the relations of civilized society. In such a field Mr. Byers, Chief Engineer of Maintenance-of-Way, Missouri Pacific Railway has reaped sheaves of information which he has threshed out and winnowed and garnered into his work on the "Economics of Railway Operation."

A mode of transportation which was originally but the combination of the service of the stage coach and the carrier's wagon upon a turnpike road with an improved surface has appropriated nearly every advance that has been made in the application of the results of scientific research to the welfare of mankind. This appropriation of almost the sum of human knowledge in a concrete form has been accompanied by an extension of its field of usefulness over the face of the earth. But nowhere else has the development of railway transportation been so rapid as in the United States and in no other country are railways operated under more diversified conditions or on so extensive a scale.

The service of railway transportation is a complex of mental and physical activities, exerted through the intervention of appliances and devices controlled by agencies in separate places and at different times. This complex of activities must be so coordinated as to work together for the successful accomplishment of a specific purpose: the transmission of persons and things with safety, convenience and dispatch. Upon first thought it seems impracticable to condense within reasonable limits an adequate description of what may be termed the art of railway operation. For it should comprise a reference to every fact essential to a comprehension of the present state of that art if it is to be of value to those who are associated in its practice or who desire to obtain a theoretical acquaintance with it.

The art of railway operation is like a maze of many colored threads from which each independent operator is disentangling here and there a strand for a web of his own weaving, but for the entire mass to be utilized in a fabric of orderly design, some clue must be found to the unraveling of the mingled skeins. This clue is to be sought through the systematic analysis and classification of the facts essential to the practice of the art, and this service has been undertaken in the work of nearly seven hundred pages under review. Organization is the clue to the labyrinth. It is given to but few men to have acquired an adequate conception of efficient railway organization from personal experience, for such opportunities are confined to those only who have attained the higher offices in railway service. Therefore the many must obtain that conception from the few who have enjoyed such an opportunity. Let us see what the author has done in this connection.

The aim and intent of the organization of individual activities is their coordination to a common purpose. Any combination of individuals may be readily coordinated under a single official so long as their field of action is under his personal observation; but when that field extends beyond his purview, it becomes necessary to dispute some part of his authority to subordinates. Here is the parting of the ways between two methods of organization, the departmental method or the delegation of power in specific lines of activity to deputies who remain under the direct supervision of the central authority, and the divisional method or the delegation of authority over these several lines of activity to a single deputy in a specific field of action. Contention as to the relative advantages of these methods has existed since warfare became a recognized profession. The officer on the staff favors the departmental method, while the officer of the line prefers the divisional method; and this contention has accompanied the development of isolated railway companies into connected systems of thousands of miles of line.

A consideration of this problem may be simplified by viewing the railway company as a corporation, apart from its functions as an instrumentality of transportation. The corporate authority is lodged in the board of directors. There responsibility must ultimately rest as to matters affecting corporate powers and obligations, and thence supervision should be directly exercised over matters of policy and finance. The delegation of power as to such matters must remain within the personal observation of the board of directors, and therefore the business of the treasury and the legal relations of the corporation are of necessity controlled by the departmental method, regardless of the extent of the field of corporate action.

The organization of a railway company as an instrumentality of transportation rests on a different foundation. Efficiency in the performance of certain functions is the purpose in view. That purpose may be defined as the coordination of the resources of static and dynamic engineering for the transmission of persons and things with safety, convenience and dispatch; and this definition may be considered as the summation of the art of railway operation. This art has been developed by practical experience in the combination of the functions once separately performed by carriers and by coach drivers in the control of vehicles over turnpike roads.

In the early stages of this development, the co-ordination of these functions under a single official was practicable. With the extension of service over longer lines, and with increase of traffic, there came a delegation of power along specific lines of action which resulted in the establishment of the roadway, the mechanical and the transportation departments. In the further stages of railway expansion these lines of action extended into regions beyond efficient supervision from a single center. To overcome this difficulty it became necessary to divide these regions into separate fields of action and to delegate to a deputy in each division some of the power before exercised directly from the central source of authority.

The problems here presented are these: at what stage in the expansion of a railway system should the divisional method of organization be introduced, and to what extent should the central authority be delegated to the deputies in charge of the divisions? The facts and arguments bearing on these problems are set forth in the work under review. Descriptions are given in detail of actual organizations, with suggestions as to their modification to suit systems of different magnitudes or which are operated under other conditions.

As a general proposition, there are two elements involved in any complex activity: improvement in methods and coordination in their application to a specific purpose; or briefly, progress and uniformity. These elements are by nature in opposition, and the character of any organization is affected by their relative activity. The most efficient organization is that in which their reaction has been resolved into a diagonal of forces in the line of least resistance. Here a distinction is to be drawn between the establishment of methods and their application to concrete cases. It is the distinction between theory and practice that affords a standard of delimitation between the authority reserved to the department chiefs and that transferred to the division superintendents; a matter which is fully discussed by Mr. Byers.

This line of demarcation may be more readily drawn in matters of a physical or technical nature than in those which pertain to the transportation service proper; that is, to the transmission of persons and things. For here an additional factor becomes active in the transition of control over the service as its performance passes from one division to another. It is not an isolated service but a successive service, which must be coordinated as to the time and place for it to be efficient. It is a continuous campaign, conducted incessantly, in which many agencies, widely dispersed, must each of them perform a certain act at a certain time in a certain place in order that a multiplicity of interdependent movements may continue without interruption. Here the art of railway operation is put to the test. Its successful results depend upon the cooperation of those who establish methods with those who apply them. They must provide for the safety and comfort of passengers from the time that they enter the station at the beginning of their journeys and for carrying them promptly as advertised to their destinations. Commodities must be properly loaded and dispatched and their delivery in good order ensured.

To accomplish these requirements efficiently, the art of railway operation includes the preparation of time tables, of train rules and of station rules, of regulations for the loading and routing of freight cars, for collecting them into trains and for their subsequent distribution, for tracing their movements and for inspection of their condition, as well as for other operations incidental to the main service of transportation, and all this in such detail that one-fourth of this book of nearly seven hundred pages is devoted to a description of them. It is an epitome of the latest and most improved methods and devices in use on our great systems, and it fulfils the purpose herein before adverted to; inasmuch as it contains a statement of the facts essential to a comprehension of the present state of the art of railway operation, and is therefore of value to those who are associated in its practice and to those who are desirous of obtaining a theoretical acquaintance with it.

As the corporate powers and obligations of a railway company are not organically connected with the service of transportation, so the same may be said of that field of activity which is covered by what is known in our railway parlance as the traffic department; a term applied in Great Britain to our transportation department. The assertion that this department is not a component of transportation service may not be obvious, yet it can be entirely severed from that service without affecting the efficient transmission of persons and things. The traffic department is essentially an organization for collecting the revenue derived from the performance of that service. The exigencies of competition has given it a factitious prominence in popular opinion, because to it has been assigned the fixing of rates and incidentally the power to adjust them to the relative advantage or disadvantage of individuals and of communities. Remove the necessity for competition, petrify the rates, and the traffic department will shrink to the functions of a toll-gatherer. In support of this proposition, it may be stated that in this work on railway management, while four hundred pages are devoted to the roadway, the mechanical and the transportation departments, the chapter on the freight traffic department takes up five pages and to that on the passenger traffic department but a single page is given.

Incidentally to the general scope of the work, there are chapters descriptive of the treasury, the law and the auditing departments, as also of the purchasing, testing and distributing of

*Consulting Engineer, 374 Fifth Ave., New York City. Present address, Villa Gascoyne, Alassio, Italy.

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supplies, to the police service and to the system of fire insurance. Attention is also paid to the analysis of the cost of operation. This may be satisfactorily treated with reference to a particular system, where there is an approximate uniformity in the conditions which affect the character of the comparison; but no application of the data acquired in the analysis of the operation of one system can be applied with profit to an analysis of the operation of another, until some standard of comparison has been devised that is common to both.

Engine mileage means one thing on one system and something else on another. Passenger mileage is an absurdity when applied to the cost of the service rendered. Ton mileage is a metaphysical abstraction in view of the characteristic features of freight rates and freight classification, of the proportion of dead weight to paying loads, of empty to loaded train and car mileage and of other things which affect a comparison of the cost of service under different conditions and circumstances.

This aspect of the cost of operation Mr. Byers has not considered. He has been content to describe the methods that are in vogue without reference to their unfitness for practical purposes or to their misleading effect when utilized to maintain a political thesis. Perhaps it is as well to leave the matter for the present in this state, as it is yet far from a satisfactory solution. The Committee on Statistical Inquiry of the American Railway Association has it now under consideration. With the light that will be thrown upon it from information gathered at first hand, and under its intelligent treatment by experts in railway management, we may hope for the determination of a unit of efficiency which will be available as a standard for comparison of the relative cost of operation on different systems. This must be the first step toward the creation of the science of railway economics. Meanwhile we may assure any person interested in the subject that they will find in Mr. Byers' work a valuable contribution to an understanding of the art of railway operation.

ESSAYS IN MUNICIPAL ADMINISTRATION.—By John A. Fairlie, Ph.D., Professor of Administrative Law in the University of Michigan, Author of "Municipal Administration," etc. New York: The Macmillan Co. Cloth; 5¾ × 9 ins.; pp. 374. $2.50, net.

Professor Fairlie has won for himself a high place among the close and discriminating students of municipal government. He here brings together in convenient form nineteen essays and addresses previously accessible only in the pages of various journals and society reports or else not accessible at all.

The essays fall in three main group "problems of organization and the legal relations of cities to the state"; "municipal functions and activities"; and observations on European municipal government, made while the author was abroad in 1906. In addition, there is a brief paper on Instruction in Municipal Government—what it is (or more generally what it isn't), and what it might be, in elementary and high schools, colleges, universities, and technical schools.

Most of the papers deal with municipal problems or events as they have shaped themselves during the past five to ten years; but some review earlier or longer periods, as "Municipal Corporations in the Colonies," and "American Municipal Councils." One of the broader and more unusual studies is entitled "Revenue Systems of American and Foreign Cities." Of specific developments in a single city we mention an interesting review of "The Street Railway Question in Chicago," which is brought well into the year 1907.

The foreign cities visited by the author in 1906 are located in Great Britain, Germany, Austria, Hungary and Italy. Many interesting and suggestive facts regarding the government and the activities of these cities are given.

The make-up of the book is good, it is provided with a usable index and its contents are such as to make it well worthy of ownership by any and all serious-minded students of one of our greatest problems, the government and the proper functions of municipalities.

Steam Engineering Forty Years Ago.

ENGINEERING REMINISCENCES.—Contributed to "Power" and "American Machinist." By Charles T. Porter, Hon. M. Am. Soc. M. E., Author of "Mechanics and Faith," etc. Revised and enlarged. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 335; folding and other plates and text illustrations. $3, net; English price, 12s. 6d., net.

The venerable Chas. T. Porter, now past 80 years of age, was induced some time ago to contribute to the columns of "Power" and the "American Machinist" some reminiscences of his life and work in the development of the high-speed steam engine. This series of articles has now been brought together in book form; and the volume is a valuable contribution to the history of American engineering.

Mr. Porter began his business life as a lawyer and was led to take up mechanical engineering in the early '50's, when he had a client who had patented a mechanical stone-dressing machine. His work as a pioneer in the development of the high-speed steam engine during the years from 1858 to 1882 was well known to the steam-engineers of a quarter century ago, who are now fast passing away.

The book is written in conversational style and with a frank recital of successes and failures which make it highly entertaining. The young engineer can learn many lessons in practical business from Mr. Porter's stories of the ventures which proved failures as well as those which were successful. Portraits of many well-known engineers illustrate the book.

It must be borne in mind, of course, that the book makes no pretence to be an impartial and complete history of the field of engineering to which it refers. Mr. Porter has merely set down his personal experiences and those of his associates and contemporaries from his own personal viewpoint. If more engineers of distinction who pass the three score and ten milestone would write similar reminiscences, the history of the profession would be much enriched.

A POCKET-BOOK OF ELECTRIC LIGHTING AND HEATING.—Comprising Useful Formulas, Tables, Data, and Particulars of Apparatus and Appliances, for the Use of Central Station Engineers, Contractors and Engineers-in-Charge. By Sydney F. Walker, R. N., M. Inst. E. E., M. Inst. M. E., Assoc. M. Inst. C. E., etc. New York: The Norman W. Henley Publishing Co. Leather; 4 × 6½ ins.; pp. xxviii. + 438; 272 illustrations in the text and 146 tables. $3.

The author's stated purpose in compiling this book has been to place in a single small volume the essential data and information on electrical apparatus, as manufactured and in common use to-day, so that it will not be necessary to search through many catalogues and books that usually cannot be found when most desired. Here are given dimensions, weights, power required or furnished, efficiencies, etc., of different commercial makes of apparatus in the most familiar fields.

The matter has been arranged in eight sections with numerous subdivisions. The main divisions are: (1) Electrical units, (2) generators and transformers, (3) accumulators, (4) switches and switchboards, (5) distribution systems, (6) instruments, (7) arc and incandescent lamps, (8) heating apparatus.

In the section on electrical units there is a brief résumé of the magnetic and electrical properties of materials, and of the laws of the flow of direct and alternating currents. The remaining sections and sub-sections treating commercial types of machines and apparatus, take up first the common characteristics of the class, then the peculiar features of the different companies' products and show tables and figures giving the dimensions, weights, outputs and inputs, etc., etc.

The selection of material and the arrangement is in many ways commendable and the book will be found useful by all having to work with British electrical machinery. Its field, however, seems restricted — perhaps intentionally — to machinery adapted for British projects, for the amount of American or German machinery described is very small. A similar book, or a truly American edition of this one; that would present in such convenient form similar data and notes on apparatus for American projects would be useful. For Americans studying English types of electrical apparatus this handbook should be invaluable.

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HANDBUCH FUER EISENBETONBAU.—Edited by F. von Emperger. Vol. I.: History of Development and Theory of Reinforced Concrete. Prepared by M. Foerster, Dr. Max R. von Thullie, K. Wienecke, Ph. Völker, J. A. Spitzer, J. Melan. Berlin, Germany: Wilhelm Ernst & Sohn. Paper; 7¼ × 10½ ins.; pp. 449; 564 illustrations in the text and 1 folding plate. 18 marks; American price, $7.20.

With the appearance of this volume, the "Handbuch für Eisenbetonbau" is presumably completed. [See reviews in this Supplement: Vol. III., Parts 1 and 2, May 16 and Aug. 15, 1907, respectively; Vol. II., March 12, 1908.] Vol. I. contains (1) a historical review of the development of reinforced-concrete construction, with some notes also of the origin and development of the artificial cement industry; (2) a discussion of the chief tests on columns, beams and arches of reinforced concrete; and (3) the theory of design and analysis of reinforced concrete. The latter is intermingled with the discussion of tests, in the three principal divisions of the book, which deal respectively with columns, beams and arches. Six authors have collaborated in the production of this volume, under the general direction of Mr. F. von Emperger. As a natural result the text is of somewhat variable quality. The discussions of test results are very lengthy, and through lack of grouping and condensation do not conduce to maximum clearness. The abundant citation of test figures and the extensive bibliographies appended to each chapter are features of distinct value.

L'EDILITE TECHNIQUE.—Scientific and Practical Review of the Art and Technic of Hygienists, Architects, Engineers and Constructors. Official Organ of the Union des Services Municipaux Techniques et des Travaux Publics. Monthly. Vol. I., No. 1, January, 1908. Paris, France: Le Siège Social (28, rue Serpente). Paper; 8½ × 12½ ins.; pp. 16. In France, 20 francs per year ($4); foreign, 25 francs per year ($7.50).

The French language, with the readiness of direct derivation, adopted from the parent Latin the word "édilité," significant of the science which was practised by the edile, that official of ancient Rome, to whom was assigned the general supervision of the physical management of the city. The word, the exact analogue of which is lacking in English, covers the whole field of municipal engineering, the control of public utilities, the construction and design of sewer and water systems, sanitation, hygiene and public accounting. In furthering the study of this science there was organized in France in 1907 the Union of Municipal Technical Services and Public Works, of which society "L'Edilité Tech-

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nique" is the official organ. The first number, which we note here, does not give much of an idea of what the new journal will cover, as it consists mainly of notices of its organization and accounts of the incorporating meetings of the association which it represents.

Railroad Engineering.

Reviewed by W. D. TAYLOR,* M. Am. Soc. C. E.

THE ELEMENTS OF RAILROAD ENGINEERING.—By William G. Raymond, C. E., LL.D., M. Am. Soc. C. E., Professor of Civil Engineering and Dean of the College of Applied Science, The State University of Iowa. Vol. II. New York: John Wiley & Sons. London, England, Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 405; folding and other plates, and numerous text illustrations. $3.50; English price, 15s., net.

Railroads in America are built for a single avowed purpose; namely, to make money for the projectors.

In such wise does Professor Raymond begin the text of the new work for which railroad engineers of the country have been waiting a long while. Perhaps the author is correct as to the primary purpose of railroad construction, but it is suggested that in a work of this character, to be used primarily by students preparing to enter the service of the railroads, it would have been only fair to point out that the construction of most of the roads has brought about some very much more widely beneficial results than the making of money for the projectors. Indeed, it might not have been improper to state that at the present time in the United States most of the railroads are not fulfilling very satisfactorily the purpose which the author ascribes to them, and that they are being used by the powers that be for almost every purpose under the sun except that of making money for the projectors; still it is to be hoped that this condition is not to continue indefinitely.

Though the reviewer knows full well that the author would not willingly inculcate into his readers and students any unjust bias toward the railroads, he will profit by the opportunity to say that in all fairness the railroads which employ such a large percentage of the output of engineering colleges have a right to ask that the teachers in these colleges, the teachers of the future railroad men of the country, shall see to it that the students do not leave their *Almae Matres* with minds poisoned by the present-day prejudice against transportation companies. The reviewer will say that he believes that no first-class railroad will willingly employ any young man who has been taught to believe that when he takes service under this or that railroad company that he is necessarily entering the employ of a wholly mercenary corporation.

Fortunately, there is very little in the book which would tend to influence the student's ideas in the direction objected to, but the author's comments in regard to over-capitalization and stock watering do not state all that is favorable to the railroads on this much-hackneyed subject, though the popular view is very clearly though briefly set out. It might be pointed out here that the author's commendation of the conservatism of those companies that charge a large part of the cost of reconstruction improvements to operating expenses is a commendation of a policy directly contrary to the wishes and instructions of the Interstate Commerce Commission.

The reviewer regrets that the author did not expand into as much matter as is embraced in the whole of the present work the subjects (and those allied with them) treated of in the 16-page introduction. It might be said that the author has devoted 313 pages to the minutiae of railroad engineering while devoting only 16 pages to the broad principles governing the science. It might be claimed that the broader studies of engineering as a profession might best be taken up in a work or school of political economy, but the reviewer feels sure that, just as it has been found best to have engineering students secure mathematical instruction from engineer teachers, so should they receive their economic instruction from engineer teachers.

This work will probably become at once the standard text-book in engineering colleges for those courses which have become known as Railway Economics. And there will be many a student who will receive no further instruction in railway economics than what is embodied in this work. There is danger that such a student will leave his *Alma Mater* with a mental picture of a railroad as a long narrow strip of land joining its terminal cities, and made up of cuts and fills, tunnels and bridges, ballast, ties, rails, fastenings, grades, curves, cars and locomotives. If a student with such an outlook enters railroad service and does not change his viewpoint, he will be found thirty years hence still squinting through the telescope of his transit while some present-day brakeman, telegraph operator, freight clerk, or section hand will be throwing him off notes from the rear end of a train to tell him what to do the next day.

Except as to scope, there are very few serious objections to the work. The diction is remarkably clear and concise and the typography and punctuation excellent, points in which some recent works of a similar nature have been sadly deficient. There is an excellent table of contents and a good index. It is believed that the use of the book would have been made easier if the part and chapter number had been printed at the top of each page. The work is evidently written primarily for the young engineer student, but it is to be regretted that the author did not take us more into his confidence and advise us how he contemplates that the work should be placed in our curricula. The author has labeled the new work as Vol. II., while Railroad Field Geometry, which is in preparation, is to form Vol. I. and the Railroad Field-Book, which is also in preparation, is to be Vol. III. Does this indicate that the author has concluded that the old method of following work in the field-books of Henck, Searles, Carhart, Nagle or Allen, with a study of Wellington, Johnson or Webb should be reversed in our curricula? If so, the reviewer believes that the engineering profession will not concur. But perhaps we should not judge until we see what the new field-book will contain.

The present volume consists of the Introduction, Parts I., II., III. and an Appendix.

The Introduction contains articles on the inception of railroad enterprise, company formation, stock, bonds, engineer estimates, construction, operation, failure, over-capitalization, stock watering, railroad valuation, relation between railroads and the public, and the duty of the engineer. This is the subject matter referred to above as being condensed into 16 pages.

Part I. treats of The Permanent Way, with separate chapters on alinement, rails, fastenings, ties, ballast, bridges, culverts and structures, turnouts, side tracks and yards, elevation of the outer rail, and signaling. Just here one would ask why there should not have been a chapter dealing specially with the right-of-way, its purchase, care, records, maps, drainage and relations to adjoining property.

Part II. deals with The Locomotive and Its Work, with separate chapters on the locomotive, the work of the locomotive, locomotive and grade problems, railroad expenditures, effect on operating expense of change in the number of trains, effect of distance rise and fall and curvature on train mile costs, and problems in change of ruling grade, distance, rise and fall and curvature. It does not seem quite clear why the study of the fixed charges and of general operating expenses should be included in a division of the book devoted to the work of the locomotive. But it is particularly on the construction of this Part II. of the work that the author is to be congratulated. The reviewer feels sure that the judgment of the engineering profession will be that nowhere else have these subjects been treated so satisfactorily, so clearly, and so correctly.

Part III. deals with Railroad Construction and Betterment Surveys. There are separate chapters on reconnaissance, preliminary surveys, the location surveys, construction surveys, and betterment surveys. There is much matter in Parts I. and III. of the work usually contained in works on Field Surveying.

The Appendix is paper No. 977,* from Transactions of the American Society of Civil Engineers, being an account of the surveys for the location and construction of a new road, the Knoxville, La Follette & Jellico, of the Louisville & Nashville system across the Cumberland Mountains and the Clinch River Valley in Kentucky and Tennessee. While the reviewer will be pardoned for hoping that the author has made no mistake in inserting this paper with its discussion as an appendix to his work he would suggest that Mr. Berry's paper on "The Reduction of Gradient and Elimination of Distance Curvature and Rise and Fall on the Union Pacific Railroad," as an example of betterment surveys and reconstruction work on an operated road, would have made a second appendix more valuable still.

Without reference to the scope of the work, criticism of the book as constructed might best be directed to the lack of full bibliography, the lack of illustrative diagrams in certain parts of the work, and the brevity, even incompleteness, with which some of the subjects are treated. It is well known that some of the choicest literature on many subjects treated in this book exists in isolated articles in railway journals, all of which our well-read author has certainly perused, but his work has remarkably few references. Aside from the acknowledgments in the preface, there are references to only 18 standard engineering works. There are only 18 references in all to the publications of the Government, to catalogs, and to the papers of the engineering societies, and only two references to special articles in engineering journals. It is probable that the author would justify this by saying that the student who wishes to look further into any subject should make use of a standard index of engineering literature, but the trouble with these is that a student has to consume so much chaff to get so little grain. It would be so helpful to have one who understands the subject as well as does the author point out what should be read. As an example of good bibliography, let the reader examine the reference lists at the ends of the chapters of Turneaure and Russell's "Water Supply."

The author himself calls attention to the lack of diagrams in Part II., but says he uses them in his own teachings. Why then does he leave them out of his book? The book will be read by many a young engineer, camped on rocky hillsides, perhaps, who will have no chance to see those the author draws on the blackboard of his classroom.

As to the brevity of the treatment of some of the important subjects, take for example that of the Area of Water Way, in Chapter VI. No engineer is competent to make a layout for the ordinary bridges and culverts on any kind of a road, not even for an ordinary highway, who has not read more and who does not have a good deal more at his command than is contained in the single page of the work devoted to this subject. If the author could not have included some of the very excellent matter, diagrams and formulas contained in the excellent paper, with its discussions, of Mr. Bremner in the Proceedings of the Western Society of Engineers, the reviewer believes he should have made some very succinct references to it.

The reviewer believes that if the final great work on this subject is ever compiled it will not be the work of any one man but of several. And for this reason he believes that each writer should collect the views on each matter discussed of as many men as possible, prominent in their several fields. The error of not doing so is here apparent from the following instances:

From the text a student would have a right to infer that standard railroad practice never requires more than three 8 × 16-in. stringers

*Chief Engineer, Chicago & Alton R. R. Co., Chicago, Ill.

[*By Mr. Taylor, the reviewer.—Ed.]

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under each rail for trestle spans of from 14 to 16 ft. The standard lines in the author's own locality use four.

From the text the student would have a right to infer that standard bridge piers for single-track roads would be no larger than a length under the coping of from 18 to 22 ft. by a thickness of from 5 to 7 ft. Only piers for very short spans are made so small as this, at the present time. Recent piers supporting single-track spans 315 ft. long were 10.5 × 35.5 ft. under the coping.

From the text the student would have the right to infer that good practice never permits slopes of earth excavation to be steeper than 1½ to 1. As a matter of fact, excavation slopes in the southern part of the United States, at points where the rainfall is not excessive and where frost never heaves, are rarely flatter than 1 to 1. In the vicinity of Birmingham, Ala., earth cuts were regularly taken out by the standard lines on slopes of 1 to 1 or even steeper. The new line of the Illinois Central, extending eastward from Baton Rouge, La., has earth excavation slopes of 1 to 1.

The reviewer cannot insist too strongly upon the necessity of what is indicated above, of imparting to such students in our engineering colleges as are to take up railway work a broader outlook on the whole field of railway service than can be acquired from a close study of Professor Raymond's work in the form he has left it. Our naval students at Annapolis are thoroughly taught United States History and the objects and ends of the navy as a whole. Should a young engineer student be less informed about his chosen profession? Why should he not be taught railroad geography just as the naval student is taught the geography of the world and of the country? Why should he not have a scientific knowledge of the characteristics of railway traffic, operation, service and earnings in the different parts of the country, and of the different systems, just as a naval student has of the characteristics of the construction, organization and service of the various navies of the world?

The narrow point of view of the average college engineer may be illustrated from the two following instances: A few years ago an engineer connected with one of the large railway systems was written to for a description of his system from an engineering standpoint for the purpose of compiling a magazine article. He replied at some length and with some care by sending an account of the manner of performing track work on his road and that was all.

In conversation recently with a young engineer graduate who wore a Tau Beta Pi* badge, and who was working for an electric road that was busily constructing its line parallel to a steam road of long standing and of well established traffic, for the purpose of competing with the steam line, the reviewer expressed a doubt as to whether or not the new electric line could be made to pay. "Oh," said the young engineer in all seriousness, "I get just as good a salary from this company as any of my classmates got who entered the employ of the steam roads." It is this point of view and the habits of mind that accompany it that so often causes the operating department of a railroad to look upon its engineering department as a necessary evil in times of business activity, and which explains the readiness with which the average general manager reaches up first for the engineer payroll when retrenchment is in order in times of business depression. The reviewer does not claim that the engineering colleges are wholly responsible for this condition of affairs, but he feels quite sure that a student's outlook is oftentimes more helpful in holding a job than his knowledge of mathematics, and with proper care the colleges can always impart a favorable outlook even when they fail to get in the mathematics.

From the author's announcement it may be inferred that he is now at work in getting ready his proposed two field-books. There are good field-books already in existence. It is difficult to see how one can be prepared that will be any very great improvement on some of those now in use. But the reviewer believes sincerely the final great work on the subjects briefly treated in the present volume is not yet compiled. Professor Raymond has made a most excellent beginning, but as yet it is little more than a beginning. Let us hope that this author, who has both the time and the fitness for the work, will lay aside his other aspirations and, working in the direction in which he is so well started, exhaust the field, as Wellington's great book did in its day, and as Camp's "Track" did when it was written.

In his mind's eye the reviewer sees such a work printed in a single volume of about the size of the standard Official Guide, and on just such paper and with Wellington's plan followed of putting the more technical parts of the subject in finer print. This work is to contain maps of all the standard railway systems of the country, with a brief account of the earnings, operations and the traffic problems of each. The subjects of Professor Raymond's brief Introduction will be expanded into a scientific engineering treatise on railway economics, and the three parts of the present work will be rearranged and fitted into the work so as to make up a harmonious whole. If Professor Raymond will undertake this work it is believed that a work can be constructed which will compare with the present volume in its effect and usefulness about as Wellington's Economic Theory did with the little work he first compiled.

*A college fraternity, membership in which means excellence in engineering studies.

Paints, Pigments and Varnishes.

Reviewed by ROBERT JOB.*

ANALYSIS OF MIXED PAINTS, COLOR PIGMENTS, AND VARNISHES.—By Clifford Dyer Holley, M. S., Ph. D., Professor of Industrial Chemistry, North Dakota Agricultural College, and Chemist on the Staff of the North Dakota Experiment Station, and E. F. Ladd, B. S., Professor of Chemistry, North Dakota Agricultural College, State Chemist and Food Commissioner for North Dakota. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5 × 8¼ ins.; pp. 235; 10 text illustrations and 1 plate. $2.50.

MODERN PIGMENTS AND THEIR VEHICLES.—Their Properties and Uses Considered Mainly from the Practical Side, and How to Make Tints from Them. By Frederick Maire, Author of the "Modern Wood Finisher," etc. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4¾ × 7½ ins.; pp. 266. $2.

The "Analysis of Mixed Paints, Color Pigments and Varnishes," by Clifford Dyer Holley and E. F. Ladd, is one of the most useful works upon paint composition and analysis yet published. It will be of great value to the paint student and analyst, while also, owing to the authors' connection with North Dakota paint legislation, additional interest will be felt in the general discussion of the problem of securing efficient paint.

In the introductory chapter, Commissioner Ladd gives a clear statement of the causes and conditions of the paint trade which made legislative action necessary. The falsifying of labels has been one of the abuses which has grown up, particularly since the tremendous increase in the manufacture of ready-mixed paints during recent years. This practice by unscrupulous manufacturers resulted in loss to the public, and the passage of laws which aimed to correct the recognized evils was a natural sequence. The use of labels which make no false or misleading statements is merely a matter of common honesty, and reasonable laws enforcing such practice are an aid not only to the general public, but also to the honest manufacturer.

As to the value of the so-called "fillers" Prof. Ladd appears to be in doubt. The reviewer's experience for many years in railroad work is directly at variance with this, for he has found that the "fillers" when in proper proportions and of correct physical condition decidedly increase the durability of the paint, particularly when the service conditions are severe, while at the same time the cost is lowered. If material of this character is stated by the manufacturer to consist of pure white lead or zinc oxide or oxide of iron, the statement obviously is false, and the addition of the "fillers" then constitutes an adulteration. With a proper system of labelling, however, the material is placed upon its merits and the price is regulated by competition.

Beyond the first chapter the book was written by Professor Holley and will have a wide use, both because of its detailed information regarding the composition of the pigments now in general use, and also because of the directions for the analysis of the paints. In the chapter on Japan drier, methods for practical testing and valuation are presented. A chapter upon the analysis of varnish furnishes the present knowledge upon this subject. Unfortunately, even the best known methods for analysis of varnish give very misleading results at times, and much further study will be required before this branch of analysis is placed upon an exact basis.

The chapter upon the practical testing of varnish offers much more immediate promise of value than that upon its analysis. It has long been the belief of the reviewer that a simple series of tests will ultimately be devised which will enable one in the space of a day or two to form an accurate opinion regarding the service value of a given sample of varnish.

The work closes with useful tables of weights, etc., and a good index.

"Modern Pigments and their Vehicles," by Frederick Maire, is a simply expressed, readable book which is certain to be equally useful to the practical painter and to the paint student and analyst. A clear, working idea is given of paint materials, particularly the pigments, while their properties, general mode of production, practical service value, and other information likely to be required is detailed.

The author (who was formerly editor of "Painting and Decorating") has had a wide practical experience with paints and painters, and puts the reader in touch with the relative values of the different pigments under varying conditions of service. In most cases, also, the reasons for any peculiar properties of the pigments are clearly stated; as, for instance, the cause of the difference in durability of ochres. Among the many good features, the chapter giving directions for the production of any of the usual tints will be especially useful to the practical painter.

By the study of this book, the painter should obtain good general ideas of the materials of which he has practical knowledge.

*Member of the firm of Booth, Garrett & Blair, Analytical Chemists, 404 Locust St., Philadelphia, Pa.

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Elevator Service.

Reviewed by WILLIAM H. BRYAN,* M. Am. Soc. M. E.

ELEVATOR SERVICE.—By Reginald Pelham Bolton, M. Am. Soc. M. E., Author of "Motive Powers and Their Practical Selection." Operating Conditions and Proportions, with Diagrams, Formulas, and Tables for Passenger Travel, Schedule and Express Operation, with the Relation of the Elevators to the Building, and Proportions and Loads of Cars. New York: The author (527 Fifth Ave.). Cloth; 7½ × 11 ins.; pp. 69; folding and other diagrams. $5, net.

This is an effort toward the intelligent proportioning of elevator service, a task for which the author's experience well fits him. For any given building and character of occupation there is a definite proportioning of elevators which will give the most satisfactory results. Such a plant should maintain a reasonably short round-trip period and interval, carry the proper capacity per hour, either or both ways, and be capable of some increase in emergencies.

Exception may be taken to the statement that each passenger requires a separate stop. In average office buildings at least one-fourth the stops will serve two or more passengers. As the full number of stops would frequently be necessary, however, the assumption provides a round-trip period which is sufficient for severe service, and has some margin under average conditions.

Evidently the important feature of the book in the author's opinion is his rating of the work of the elevator. If stops are made at every floor he claims that there is a loss both of efficiency of service and of hourly capacity. A diagram indicates that when the average number of passengers per trip each way is .4 the number of floors served, the elevator handles 90% of its maximum capacity, and at a shortened and more desirable round-trip period than with heavier loads. This diagram and the accompanying charts are intended to prove that the maximum capacity is secured by carrying equal numbers of passengers both ways, there being an increase of only 80%, instead of 100% in the same round-trip period when the travel is all one way. Also that the hourly capacity drops off beyond a loading of about .7 to .8 the number of floors served. These figures the reviewer is unable to follow. His own computations—based on the author's data—indicate that it is immaterial how the rated load per round trip is carried, whether equally divided, all one way, or in any combination. Also that increased loads invariably mean more passengers per hour. It is true that such loads involve more frequent stops and increase the round-trip period, and that after the number of passengers reaches about half the floors served, this delay begins to impair the general efficiency. Better all-round results are therefore secured at lighter loads. A further study and revision of these diagrams as regards capacity is suggested.

These considerations lead to the conclusion by the author that the most efficient all-round service is secured when the mean load assigned each elevator per trip each way is that number of passengers which corresponds to .4 the number of floors served. This is defined as "the Bolton rating." The reviewer thinks the figure proposed is a little low, and would place it at .5.

Such a rating appears, however, to be of limited application. Its object is to insure a short round-trip period, but its rigid application results in unnecessarily short periods for low buildings, and too long ones for tall buildings. For good service these periods should range between 2 and 2½ minutes, although a somewhat shorter time is common in very low buildings, and a little longer in very high ones. For any given speed and number of floors the number of stops which may be made is limited by the permissible round-trip period, and that number may or may not be .4 the number of floors. For varying numbers of floors the number of permissible stops consistent with good round-trip service varies inversely with the floors.

The author uses the ordinarily accepted rule of 75 lbs. per sq. ft. of car platform, for maximum load, and 2 sq. ft. space per passenger, and recommends an allowance of 4 for the operator. He suggests as sizes of standard cars, 6 × 7 ft.; 5 × 6½ ft.; 4 ft. 4 ins. × 6 ft.; 4 ft. 2 ins. × 5 ft., to cover all ordinary conditions. The gate opening is stated as two-thirds the width of car. This, however, may be increased somewhat on account of the gates telescoping into the frontage space between cars.

Having placed the average number of passengers per trip each way at .4 the number of floors served, f, the provision that this number may be increased 80% when all are carried one way, together with a margin of 10% for emergencies, fixes the number of people to be provided for per trip at .8 the number of floors served. This determines the size of car. Knowing the mean speed, the round-trip period is readily computed, and from this the capacity per hour.

The reviewer's figure for loading, .5 f each way, the full round-trip number being carried one way, indicates that the car should be designed to carry as many passengers as there are floors served—with an additional 10% for emergencies—a total of 1.1 f.

It now remains to determine the number of such elevators needed. Taking the maximum service to be the handling of the building's tenants in or out, the author proceeds to determine their number, and the time within which they must be moved. The latter he has found by observation to be one-half hour for an average office building. Then follow some interesting data as to the average amount of occupied area per tenant, this varying from 80 sq. ft. in "tenfamily old-law tenements," to 365 in "large apartment hotels," and in office buildings from 100 to 150, depending upon the character of the business and the location of the building. Knowing the density of occupation, the gross tenancy is readily computed. Dividing this by the maximum capacity one way per car per half-hour, as already ascertained, gives the number of cars. The reviewer's ratio would give about 25% fewer cars for the same service.

The author's treatment of express elevators is interesting. He shows that this service should begin with buildings 16 stories high, and presents formulas for computing round-trip periods and passengers carried. A chart is submitted showing the proper division between local and express service up to 36 floors. If the upper part of the building is to be given equal service with the lower in number of cars and length of round-trip period, the chart shows that the division should be made at a level corresponding to about 60% of the number of floors. For any given number of elevators, all running local, there is a certain frequency of service. If half the cars are set aside to serve 60% of the floors, the interval is necessarily increased, and the service on the lower floors impaired to that extent. This could of course be remedied by installing additional elevators. The author shows that express service involves about 10% more elevators, for a gain of about 40% in time, but this gain is limited to the upper floors—a point which should not be overlooked. In very tall buildings three instead of two tiers of elevators should be provided. It is not clear why the author postpones this further subdivision until the locals have reached 21 floors, when he begins the two-tier service at 16.

The author shows a tendency to confuse capacity, as defined by percentage of floors served, with capacity of the full car, which are of course only indirectly connected. He also confuses rated and average travel.

In Chapter V. the author submits some interesting data when computing the average work of an elevator, but errs in stating the approximate distance between stops as 24 ft. On the .4 f basis for 12-ft. story heights, two stops are made every five floors, or 60 ft., thus averaging 30 ft. apart. This error is repeated in Chapter VIII. There is also a table showing the passengers per hour in each direction, the round-trip period, and the number of trips per hour, at various speeds, and for various numbers of floors. This table brings out clearly the fact that the Bolton rating results in unduly long round-trip periods for tall buildings, and unnecessarily short ones for low. This may of course be offset by varying the nominal speed with the height of building, and by using express service.

The author states that electric elevators are usually overbalanced by the amount of the average load. This is a common but inexact statement. If the mean load at start is .4 f, the average per round trip is only .2 f, or one-fourth the maximum. If only this average load is counterbalanced, the motor must be large enough to start and lift the remaining three-fourths—thus increasing first cost, and the starting and running currents. The best practice is to overbalance to one-half the maximum load, which reduces size of motor and reduces and equalizes current demand.

The author states that the larger the building the greater the number of elevators, and the better the service, as a result of the shorter schedule. This is only true within limits. For increased height the lengthened round-trip period would be cared for by adding elevators, thus maintaining the same schedule. For increased floor areas, the better schedule is offset by the greater distance which the average tenant has to walk to and from the elevators. Better service is given by dividing them into two or more independent groups, more centrally located.

The author's suggestion that a reserve elevator be always installed, on account of the difficulty and expense of making adjustments and repairs out of regular hours, is not likely to prove popular on account of the increased cost and floor space required.

In the table giving the average travel and load conditions for the four standard sizes of cars selected, the headings of the last two columns referring to rated and mean loads have been reversed. The expression for average distance between stops in the same chapter contains an unnecessary f.

In the chapter on "The Building and Its Proportionate Service," formulas are given for computing the hourly capacity of local and express elevators in existing buildings. In these the plus signs should all be minus. The formula for net area per floor on next page is unintelligible with the notation previously used.

The author sums up his conclusions in a large chart from which the number of elevators, local or express, their speeds, round-trip periods, and intervals, can be determined from the number of floors, their occupied area and the density of occupation—an interesting and valuable compilation. Unfortunately for the ready understanding of this chart, the author's explanatory example is confused by his assuming a 115 sq. ft. occupancy, and then working out the results on the 125-ft. basis. The chart enables one to form a judgment of the relative efficiency of existing or proposed elevator equipment.

The work concludes with a glossary of terms used in elevator practice. An index is lacking.

The value of the book would be enhanced by more detailed treatment of other types of buildings, such as department stores, hotels, apartment houses, hospitals, etc.—where the controlling considerations differ widely from those of office buildings.

It is to be regretted that a work of such range and value should be marred by the minor blemishes referred to, which will no doubt be corrected in later editions. In spite of these the book is deserving of commendation.

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The Metallurgy of Iron and Steel.

Reviewed by JOSEPH W. RICHARDS.*

THE METALLURGY OF IRON AND STEEL.—By Bradley Stoughton, Ph. B., B. S., Adjunct Professor, School of Mines, Columbia University. New York: Hill Publishing Co. Cloth; 6 × 9½ ins.; pp. 509; 311 illustrations in the text and 33 tables. $3.

For many years there has been *one* book on the metallurgy of iron and steel—Ledebur's "Eisenhüttenkunde." Unfortunately, that book is inaccessible to most English readers because it has never been translated. It is so well-balanced, so finely condensed, so clear in description, so judicial in its tone, so generally commendable where it touches on theory, that no book in any other langauge comes within the same class as it. I hope this word of commendation may induce metallurgists to learn German in order to read Ledebur: it is worth it.

Professor Stoughton's book does not replace Ledebur, and is not in the same class; in fact, it does not pretend to be. What it is, is a first-class illustrated description of the present state of the iron and steel industry, entertainingly written, splendidly illustrated, a little too detailed to be called superficial, yet not minute enough to be tiresome to anyone wishing to learn something about iron and steel. It fills a distinct gap in English metallurgical literature, in that it provides a clear, up-to-date description of the apparatus, furnaces and appliances used in the metallurgy of iron and steel.

The book does not provide an equally complete exposition of the principles underlying these processes. If it had done so, it would have been in some respects the English equivalent of Ledebur. If the author had possessed as full an understanding of the chemical and physical principles involved as he has shown of the material and physical facts and statistics, there would be nothing but praise for the volume.

The manufacture of pig iron is described very well, and of wrought iron and crucible steel fairly well. The description of the Bessemer process is very good (the author is here most at home), and the account of the open-hearth process is quite satisfactory. Defects in ingots and other castings are set forth in a rather sketchy manner. The sections on the mechanical treatment of steel and on iron and steel founding are good. The presentation of the solution theory of iron and steel and the constitution of steel and cast iron is poor: too much is left indefinite, and too much is taken for granted on insufficient evidence. The chapter on heat treatment of steel is very well written. Alloy steels are extensively discussed, the distinction between the use of an element, such as manganese, as "medicine" to ordinary steel and its use as a special ingredient to make a special steel, being very clearly brought out. The question of corrosion of iron and steel, its causes and methods of prevention, is handled in a practical manner. The section on the electro-metallurgy of iron and steel is short, but contains a misstatement as to the induced current in an induction furnace being "direct current." The chapter on the metallography of iron and steel is short, but corresponds to the relatively minor practical importance of its present development.

The book contains many minor errors in its descriptions, such as ascribing views and explanations to the wrong metallurgist. It also contains some major errors in questions of theory and calculation, such as confounding gram calories and kilogram calories, and wrong statements as to Boyle's and Avogardo's laws relating to gases. Such deficiencies require that the student using the book should carefully criticise these questions for himself before accepting the statements, or should have his attention drawn to them by his instructor, and the correct principles made clear. Assuming this to be done, the book will give to beginners an admirable picture of the iron and steel industry. It is not a book for the expert, but for engineering students it can be commended as about the best and most up-to-date introduction to modern iron and steel making to be found in our language.

*Professor of Metallurgy, Lehigh University, South Bethlehem, Pa.

The Care and Operation of Naval Machinery.

Reviewed by D. W. TAYLOR.*

HANDBOOK FOR THE CARE AND OPERATION OF NAVAL MACHINERY.—By Lieut. H. C. Dinger, U. S. Navy. New York: D. Van Nostrand Co. Cloth; 4½ × 6½ ins.; pp. 302; 4 folding plates and 124 text illustrations. $2.

This handbook of 300 pages is intended primarily for the use of those who are interested in and have to do with machinery of naval vessels. It gives concisely, but clearly, very complete information as to the best methods used in the engineering department of naval vessels and contains a great deal of information as to the current practice of the Bureau of Steam Engineering of the Navy Department in regard to the design of details, fittings and auxiliaries. In addition to the main engine and its auxiliaries, such as condensers, air, circulating and feed pumps, it deals with joints and packing, stuffing boxes, feed and filter tanks, feed-water heaters, evaporators and distillers, refrigerating plant, gages and thermometers, piping, valves, and all other machinery or fittings connected with machinery on naval vessels.

The book is thoroughly practical, giving information in connection with the various fittings and pieces of machinery, not only as to methods of running, but as to care, methods of examination, the troubles and difficulties likely to arise in service and methods of overcoming same.

Much of the information concerning various auxiliaries, such as refrigerator plants, is taken from descriptions of the manufacturers, and includes in one or two cases matter having little bearing upon marine practice.

The book would be strengthened somewhat if the author had given some reasons for his injunctions: for instance, we find on page 3 the statement, "With a Scotch boiler great precautions must be taken that the boiler is gradually heated and that one part is not cold while another is hot." While this is sufficient as a reminder to persons having to deal with Scotch boilers, a few words explaining why variations of temperature are detrimental to the Scotch boiler would have impressed the injunction more strongly upon the user of the book.

The work seems nearly free from typographical errors, although they are not altogether absent. For instance, on page 5, we find "ronds" for "rods"; on page 92, "stuffing box-backing"; on page 136, the text designates "Air-compressor cylinder" by the letter "E," while the plan designates it by the letter "B."

There is no doubt that this book will be of great use to those for whom it is intended, and of interest to all who have to deal with naval machinery.

The author, apparently, does not include boilers under the designation "Machinery" as the information given as to the operation of boilers is incidental and questions as to the care and preservation of boilers are not taken up at all.

It is to be hoped that in future editions the book will have added to it matter covering naval boilers as satisfactorily as the other subjects.

LOCAL SELF-GOVERNMENT.—Elective Town Meetings for Large Towns, with a General Legislative Bill Therefor, and the Recent Charter of the City of Newport, R. I., Based Thereon. By Alfred D. Chandler, Esq., Ex-Chairman of the Board of Selectmen of Brookline, Mass. Brookline, Mass.: The Author. Paper; 6½ × 10 ins.; pp. 68.

Arguments for the New England town-meeting system, and selectmen to run the affairs of the town between meetings, are here given, and a plan is proposed for what might be termed representative town-meetings as a substitute for meetings open to all voters in those towns that are so large as to make the old-fashioned town-meeting unpracticable. The main part of the pamphlet is condensed from an article prepared by the author at the Bi-centennial of Brookline some three years ago. Since the article was written the city of Newport, R. I., has adopted a representative-council scheme like that proposed by Mr. Chandler. The pamphlet before us presents the Newport plan.

*Naval Constructor, U. S. N., U. S. Navy Yard, Washington, D. C.

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Gas Engines.

Reviewed by LIONEL S. MARKS.*

GAS POWER.—A Study of the Evolution of Gas Power, the Design and Construction of Large Gas Engines in Europe, the Application of Gas Power to Various Industries and the Rational Utilization of Low Grade Fuels. By F. E. Junge, M. A., C. E., M. E., Member Verein Deutscher Ingenieure. New York and London: Hill Publishing Co. Cloth: 6 × 9¼ ins.; pp. 548; 8 plates and 159 text illustrations. $5.

THE GAS-ENGINE.—A Treatise on the Internal-Combustion Engine Using Gas, Gasoline, Kerosene, Alcohol, or Other Hydrocarbon as Source of Energy. By Frederick Remsen Hutton, E. M., Ph. D., Sc. D., Emeritus Professor of Mechanical Engineering in Columbia University. Third Edition, revised. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth: 5¾ × 9 ins.; pp. 562; 259 illustrations in the text. $5.

Mr. Junge's book on Gas Power is most welcome. Engineers in this country have been seeing short articles on and hearing frequent references to the remarkable growth of the large gas engine in Germany and Belgium, during the past five years; they have heard that the utilization of blast-furnace gas in gas engines has become a commonplace in Germany; they may have heard that at the Krupp works at Rheinhausen there are between 20 and 30 blast-furnace gas engines averaging over 1,000 HP. each, used for driving rolling mills, for the generation of electricity and for the blowing service—and that there are similar plants in the other large steel works; but the particulars of this practice, the constructive, operative and economic details, have been published principally in the German technical papers and have never before been brought together in a satisfactory manner in any language.

Mr. Junge has rendered a most excellent service to the engineering profession in general and to English-speaking engineers in particular, in preparing an admirable account of what has been accomplished up to the present in the production of gas power in large units, and in pointing out the enormous possibilities of future development and the directions along which such development can most advantageously be made.

Mr. Junge is an enthusiast and is crammed so full of facts and observations on his subject that they continually run over at unexpected places. The general plan of the book is perhaps not the best that could have been devised to relieve the author of his load—but it is good enough, and the appearance of valuable observations at unexpected places adds to one's interest in reading the book, even if it does not improve it as a book of reference.

The work is divided into three parts. Part I. takes up the evolution of gas power, the general economic aspects of the problem, and includes a historical and analytical study of the development of the present mode of application of gas power and a criticism of that mode. The power represented by the gases escaping from the blast furnaces of this country is at present nearly 5,000,000 HP., of which only a little over 3% is utilized in gas engines, a very much larger quantity being used inefficiently for steam generation. Here is a large field ready for the gas engine and the possibility presents itself of a large increase of the 15,000,000 HP. at present developed in this country from all sources, without any increase in the total cost of fuel. In view of the definite limits to the total amount of fuel in the world it is most important that this blast-furnace gas should be efficiently utilized.

The second part of the book, treating of the design and construction of large gas engines, opens with certain general considerations, among which those on governing are the most valuable. The practice of so-called mixed governing—that is, governing partly by quantity and partly by quality regulation with a corresponding regulation of the time of ignition, gives undoubtedly the best economy with varying loads. This practice, which has now established itself in Germany (particularly the Mees system), is practically unknown here; it introduces complication, but that is of minor account in large engines.

There follows a detailed description of the most prominent and successful of the Continental engines. The double-acting four-cylinder engine is represented by the Nürnberg (which has become the standard type, not only in Germany, but also to a great extent in the United States, though it is modified considerably in its details by the various licensees), and by the Reichenbach engines. The two-cycle type is represented by the Oechelhäuser and Körting engines. A separate chapter is devoted to each of these four engines. The details of construction, the prospects and limitations of the working cycles, the regulation, the adaptation to various services, the construction of auxiliaries, the details of the processes, the applications in various industries, the economic performance as determined by tests and other pertinent matters are discussed for each engine. There does not seem sufficient reason, however, for devoting a chapter to the Oechelhäuser engine, since it is now practically obsolete. The form of this engine built by Borsig (to which more than thirty pages are devoted), has been abandoned by that firm for some two or three years, and although another licensee (the Aschersleben Engine Co.) has undertaken its construction it is regarded in Germany as a thing entirely of the past. It is too bulky, it is constructionally bad and it has failed in many notable instances to come up to requirements. It would have been better if the author had informed his readers that he was describing an obsolete type.

The third part of the book is most suggestive and valuable. It deals principally with the applications of gas power, more particularly in the iron and steel, coal mining and coke making industries. There is a great wealth of information as to what has been done already along these lines and much valuable suggestion for the future. The influence of the adoption of gas power on the productive efficiency, capacity and economy of iron and steel works is considered thoroughly and the numerous factors which enter into the problem are treated of in detail. That most important problem, the proper cleaning and drying of blast-furnace gas, is discussed more completely than in any other publication. The pros and cons of the use of gas engines for driving rolling mills, either direct or by electricity from a central station; of the use of gas power for blowing service; of gas power versus steam power, and of other debatable points in the application of gas power to iron and steel works are presented in a fair-minded way. A similar treatment is accorded to the application of gas power to the coal mining and coke making industries, embodying suggestions which are probably destined to revolutionize much of the practice in those industries in this country just as it has been doing in Germany.

The final chapter deals with the rational utilization of low-grade fuels and its contents are already known to most engineers through the paper on that subject which the author presented to the American Society of Mechanical Engineers last December.

This work is a valuable contribution to our knowledge of the gas power problem. Its breadth of view should ensure for it a longer life than is usual with treatises dealing with the contemporary state of an art.

The new edition of Hutton's book on the Gas Engine differs from the earlier editions mainly in its more complete treatment of gaseous and liquid fuels and in an expansion of the discussion of producers and of carbureters. The subject matter generally is brought up to date in a satisfactory manner, with, however, some notable exceptions. The book is intentionally devoted to processes and general arrangements and not to constructional details. Its principal feature is its detailed classification of every process considered; for example, carbureters are divided into eleven classes, methods of ignition into ten, methods of governing into eight. This admirable practice of classification is, however, carried in some cases to an extent which seems hardly justifiable. In the general discussion of internal combustion the author gives a list of 24 "advantages of the internal combustion principle," and another list of 23 "disadvantages of the internal combustion principle." The absence of a boiler and its furnace and all the costs and difficulties that go with them might quite well have been given as *one* of the advantages of internal combustion engines, but it is surely a padding of the number of such advantages to list separately (1) the absence of boiler radiation losses; (2) the elimination of the bulk, weight and cost of the boiler and its setting; (3) the elimination of repair, maintenance, labor and first costs of the boiler and chimney; (4) the decrease of insurance risk resulting from the absence of boiler (unless offset by a producer, gas holder or stored liquid fuels); (5) the absence of the watchfulness required to operate a boiler; (6) the absence of the danger from boiler explosions; (7) the absence of an exposed flame or incandescent fuel bed which might under certain stated circumstances be a source of danger. Similarly, with the 23 disadvantages: three of these are objections to the use of jacket water (1) because of its weight or volume and the apparatus required to circulate it; (2) because of the heat which it carries off; and (3) because it lowers the mean pressure. Several of the objections are that if the various operations are not carried out properly various things will result: For example, (1) incomplete combustion causes an offensive odor of the exhaust; (2) incomplete combustion results in deposit of soot on the working parts, which will stop their action; (3) if compression is defective the power of the engine suffers; (4) if the ignition apparatus is defective the motor stops dead; (5) if the carbureter is out of adjustment the motor slows down gradually and stops. Other objections are (1) that the valves become leaky and require attention and renewals; (2) the noise of the exhaust; (3) the jar or vibration in the cylinder due to the high initial pressure and so forth. Very few of the disadvantages cited above really belong to the internal combustion principle, and most of them are trivial or easily preventable in actual internal combustion engines. The whole statement of advantages and disadvantages loses force and significance because it is inflated to three times its proper and natural dimensions.

The general criticism which has often been urged against American text-books, that (with some very brilliant exceptions) they are generally written too carelessly and hastily, receives ample justification in this particular case. In a first edition one is not surprised to find obscurities and evidences of haste, but by the time a book has run into the third edition these defects ought surely to have been remedied. In the book before us these faults are peculiarly apparent. It reads like the first draft of a book, written without verifying the quantities recorded, without digesting the information given, and without any attempt at accurate statement.

As an example, the paragraph on alcohols may be cited. This starts out with the statement that two kinds of alcohol are used in the arts and as sources of heat: Wood alcohol, $C_2H_4O_2$, and ethyl alcohol, $C_4H_6O_2$. These alcohols have actually the formulas CH_4O and C_2H_6O instead of those stated by the author. Then further on it is stated that pure alcohol has a calorific value of 28,500 B.T.U.; the actual values (high values) are 13,330 B.T.U. for ethyl alcohol and 9,500 B.T.U. for methyl alcohol. Still further on in the same paragraph the statement is made that in some motor trials the thermal efficiency of gasoline was 14 to 18%, of alcohol 24 to 28%. The comment of the author is:

These results might have been foreseen to some degree,

*Assistant Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.

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since the alcohol contains by weight a certain proportion of oxygen which is not a fuel, so that weight for weight the gasolines have more heat and power value than alcohols.

This comment has no relation to the statement which precedes it and which apparently called it forth.

Again we open at random in the first three hundred pages (the following two hundred being taken almost verbatim from various publications of Lucke and Fernald) at the paragraph on water jacketing. It starts as follows:

> Since the specific heat of water is unity it is the most convenient medium to use for withdrawing excess of heat from the metal of the cylinder and its valves.

Now, that the specific heat of water is unity is a matter of definition and has nothing to do with its suitability for a cooling medium. That its specific heat is high is a matter of importance, but even that does not make it "the most convenient medium." Liquid ammonia, for instance, has a specific heat greater than that of water. The convenience depends on things other than specific heats. Further on in the same paragraph we read:

> It is possible to utilize the heat which the water jacket will carry away, but ordinarily this is more trouble than the economy which it represents.

This sentence is typical of much of the book—it is, of course, intelligible, but it is not acceptably good Eng'ish; trouble can no more be compared with economy than time can with weight. Similarly, a few lines further on we are informed that the cooling water is usually permitted "to reach nearly the boiling point . . . so as to keep the cylinder below the point of deformation." Undoubtedly the author means below that temperature at which deformation occurs, but he does not say so, and even if it were so stated it is not primarily deformation of the cylinder that water jacketing seeks to avoid. Moreover, it is by no means the usual practice to have the jacket water heated up "nearly to the boiling point."

The reviewer has gone into what may seem to be minor and trivial points, but in this particular case he feels it is necessary to call attention to these inaccuracies and carelessnesses of statement because they occur in practically every paragraph of the first half of the book. It is a pity that they have not been rectified, for the general plan of the book is good; but until they are corrected the book is too unreliable to be recommended for the use of students.

DEUTSCHES MUSEUM.—Führer durch die Sammlungen. A guide to the collection of the German Museum for Masterpieces of Science and Industry at Munich. Leipzig: B. G. Teubner. Paper; 9½ × 8 ins.; many illustrations in the text.

The German Museum, first proposed in 1903, has the primary purpose of portraying the history and evolution of the natural sciences, the technical arts and industry. The realization of this purpose has now progressed far enough for the preparation of a complete catalog or guide, a respectable volume of 158 pages. The museum naturally is, in the main, a collection of antiquarian relics, but it contains or portrays also a certain amount of present-day work.

THE DATA OF GEOCHEMISTRY.—By Frank Wigglesworth Clarke. Bulletin No. 330, U. S. Geological Survey, George Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.; pp. 716.

As the title of the book indicates, Dr. Clarke is not advancing any new theories or reporting any new experiments in his book, but has endeavored to collect data concerning the chemical make-up of the substances that form the earth's crust, and to classify these data in such fashion as to make them available for reference. Necessarily in making such a collation, the mere setting down of the facts and authority would result in an unrelated catalogue of properties which would be of relatively small value, so the material has been carefully classified, conclusions drawn and problems stated in order to preserve the unity and proportion of the work.

The chapters take up, in order, the elements, the atmosphere, lake and river water, the ocean, wells and springs, saline residues, volcanic gases, the molten magma, rock-forming minerals, igneous rocks, the decomposition of rocks, sedimentary rocks, metamorphic rocks, metallic ores, the natural hydrocarbons and coal. Each of these is treated from a chemical standpoint, with a few necessary allusions to physical appearance, occurrence, etc. The chapters on the analyses of water and the building rocks should have a more than passing interest to the engineer, and the whole book has possibilities of reference for many besides the geologists and geochemists, for whom it is more especially intended. A very complete index adds considerably to its value as a reference work.

Tests of Cement Mortars.

PORTLAND CEMENT MORTARS AND THEIR CONSTITUENT MATERIALS.—Results of Tests Made at the Structural-Materials Testing Laboratories, Forest Park, St. Louis, Mo., 1905-1907. By Richard L. Humphrey and William Jordan, Jr. Bulletin No. 331, Series R, Structural Materials, 3; U. S. Geological Survey; George Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9¼ ins.; pp. 130; 20 plates, 22 text illustrations and 14 tables.

The application of theory to engineering design must always be controlled by the results of experiments upon the behavior of material, which experiments must be in such numbers and of such accuracy that they may be relied upon within the limits of the design. To be of value they should be carried on under one direction, having facilities for accurate and complete work and time to develop and adhere to a comprehensive scheme of action. Obviously, it is to the Government or to some richly-endowed corporation, like the Carnegie Institution, that engineers look for the continuance of this work.

In 1904 the Government established at St. Louis, primarily as a part of the exposition held there, a laboratory for the testing of structural materials. This laboratory, under the direction of the U. S. Geological Survey, continuously since that time has been making extensive tests on materials, principally, if reports can be judged, on concrete and its constituent parts, probably because these new materials have never had the extensive tests that have been made in the past on other widely-used structural materials. The fact that the Watertown Arsenal and the U. S. Forest Service, two other federal bureaus, are carrying on extensive experiments on steel and timber, may also have influenced the directors of the St. Louis laboratories to confine their attentions to the other great building materials, stone and concrete.

The volume noted in the headpiece above is the first report of the results of tests in the Forest Park laboratories, although the survey has issued two other reports, one dealing with the behavior of structural material at the San Francisco earthquake and fire and the other describing the equipment of the testing laboratories. The tests just reported are preliminary to an extensive investigation into the properties of concrete. In order to start on a correct basis in the more important beam and column tests, over 25,000 tests were made, representing a year's work in field and laboratory, looking into the tensile, compressive and flexural strength, and the chemical analysis of cements, and the strength of mortars made of different kinds of sand, gravel and crushed stone from various localities in the United States. The former of these series was made upon each of seven standard brands of cement and upon a carefully-made mixture of the seven, in order to determine the uniformity in quality among the various brands. The latter of the tests was made to gage the value of the various aggregates which are used in the different parts of the country.

There are very few deductions made from the established data; these are left to the reader, who may consult the tables for his own use. In fact, this preliminary report is not of the value that it is expected will be attained in the future, but it contains some interesting information as to the standardization in the qualities of the various cements, which, as no trade names are given, cannot aid the sale of any particular brand, but rather gives confidence in the general production of this country, since the variation found was very small. The relative value of sands, gravels and crushed stones from different localities may prove helpful to engineers who are undecided as to what kind of aggregate to use on certain work, provided that work happens to be near one of the places from which the stones used in the experiment were taken, or that the local stone or gravel bears a resemblance to that tested. In these mortar tests the effect of the grading of the aggregate, both natural and artificial, has been investigated with results somewhat similar to those previously announced by Mr. Sanford E. Thompson, M. Am. Soc. C. E., and Mr. William B. Fuller, M. Am. Soc. C. E., in their papers before the American Society of Civil Engineers on "The Laws of Proportioning Concrete."

On the whole, this first report can only be regarded as a promise of larger things to come when the laboratory gets beyond the preliminary stage.

THE COPPER HANDBOOK.—A Manual of the Copper Industry of the World. Vol. VII. Compiled and Published by Horace J. Stevens, Houghton, Mich. Cloth; 5¾ × 9 ins.; pp. 1228. $5.

A series of mishaps, comprising a fire that partially destroyed the plates, and a Pasteur treatment following the infliction of a wound on the author by a rabid cat, so delayed the preparation of the detailed mine descriptions which have formed a considerable part of the annual edition of this handbook, that it was decided to issue the 1907 edition with these descriptions in the same form as in the 1906 edition. With the exception of these chapters, the remainder of the book has been entirely rewritten or revised from the various issues, which we have reviewed in the past. These revised chapters comprise some 140 pages, and are concerned with the history, geology and metallurgy of the metal with which the book treats.

HOW TO USE SLIDE RULES.—By D. Petri-Palmedo. New York: Kolesch & Co. Flexible cloth; 4 × 7 ins.; pp. 56; illustrated. 50 cts.

Every instrument maker who has a special kind of slide rule to exploit publishes, to accompany the rule, a manual which gives explicit instructions how to use the instrument. All of these manuals have a certain similarity and all are quite efficient in teaching the novice how to use this labor-saving device, which should be part of the equipment of every engineer. The little book noted above is more compact than the usual treatise, but otherwise is like many others

Godfrey's Tables
Godfrey's Concrete

Monongahela Bank Building, Pittsburg, Pa.

DEAR SIR:—I beg to announce that in addition to my book of Tables (a useful collection of data for structural designers' use) now in its second edition, I have issued a book entitled "CONCRETE." This contains 444 pages of information on plain and reinforced concrete and related subjects. Sound engineering and plain rational theory are set forth in this book in a way not approached in any other work. If you are in any way interested in concrete design or construction, you will want this book. I am publishing these two books and have them for sale. The price of the book of Tables is $2.50, or $2.00 to clubs of 5. The price of Concrete is $2.50, net. Yours very truly,

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in its contents, particularly in the many complicated rules regarding the placing of the decimal point, the use of which in slide-rule work is one of the marks of the beginner, for the experienced operator rarely attempts to place the decimal point by anything but inspection.

arnegie Institution Researches on High Steam-Pressure in Locomotives.

Reviewed by G. R. HENDERSON,* M. Am. Soc. M. E.

HIGH STEAM-PRESSURES IN LOCOMOTIVE SERVICE.—By William F. M. Goss, Dean of the College of Engineering, University of Illinois, Urbana. Washington, D. C.: The Carnegie Institution of Washington. Cloth; 6¾ × 10 ins.; pp. 144; 120 illustrations, mostly in the text, and numerous diagrams and tables. $1.25.

This book is characteristic of Dr. Goss' very clear and interesting manner of writing for publication. While the information embodied is given in a concise way for convenient reference, yet the matter is also accompanied by full tables and other data, so that the student can satisfy himself that the deductions drawn are based on a correct analysis of the results presented, and also can, if he so desires, glean additional matter of interest.

The Introduction gives a summary of the conclusions of the work, and in fact presents in a nutshell the general results accomplished. These it is stated, apply only to single-expansion locomotives, using saturated steam, but they have been made under conditions of steam pressure varying from 120 to 240 lbs. per sq. in., and the water rate and coal consumption have been determined for various intermediate pressures. These results show briefly that the higher the pressure the smaller the possible gain resulting from a given increase in pressure. Attention is called to the fact that operation under increased pressures requires a very high order of maintenance. The difficulties to be met with, both in boiler and in cylinder, when using these high pressures, are so great that they overcome largely the benefit of economy due to the increased pressure and may incidentally produce greater loss than gain. Attention is also called to the fact that with waters which contain foaming or scale-making ingredients the high pressure is a very serious obstacle to the proper operation of the locomotive, and while this has been realized in practice for many years, yet it is certainly a great satisfaction to have this demonstrated so clearly and conclusively by the experimental locomotive where the conditions during the different tests were identical as far as water and fuel are concerned.

The first chapter treats of the research and the means employed in its advancement. A brief history is also given of the work previously accomplished at Purdue University. The grant from the Carnegie Institute of Washington, announced late in the fall of 1903, made possible the complete series of tests, the results of which are embodied in this work, and the benefits of these tests to the railroad community should be very great. The chart showing the arrangements of the tests under the different pressures gives a perfectly clear conception of the work accomplished, and acts as a reference index to the individual items in the log printed in the appendix. Speeds from 20 to 60 miles an hour were maintained with the reverse lever in various notches, and the runs were of sufficient duration (where the steam capacity of the boiler admitted) to give results which could not be considered spasmodic or emergency. These tests were all made on the locomotive known as "Schenectady No. 2," as the old locomotive, "Schenectady No. 1," was not suitable for the high pressures which were studied.

The second chapter deals with the difficulties of operating under high pressures. As referred to above, it was found that while the locomotive No. 1, which carried but 140 lbs., was practically clean after having run in the laboratory for six years, locomotive No. 2, carrying a pressure of 200 lbs. and upwards, required new side sheets after running about 30,000 miles; and that with pressures as high as 240 lbs. the water delivered by the injector deposited so much scale in the check valve and in the pipes that very unsatisfactory operation resulted, and they were compelled to run on distilled water at the higher pressures. This point will no doubt be of great interest, as the water was received from the same source, both for the earlier engine and for the present tests, and it speaks eloquently in behalf of those who have to maintain locomotives under the water conditions which exist in the western part of this country.

The leakage under high pressures was also considerable, although a special effort was made to reduce this to a minimum, and it is these facts of leakage and repairs that mitigate against the advantages obtained by the increased economy of using such high pressures.

The third chapter treats of the boiler performance and embodies a number of diagrams which are very familiar to those who have followed Dr. Goss' work in locomotive tests in recent years, and also those reported by the Pennsylvania R. R. at the St. Louis tests. One significant fact brought out is that the evaporative efficiency is but slightly effected by the changes in pressure, probably very much less than many of us expected. Dr. Goss states that, as between 120 and 240 lbs. boiler pressure, the difference in the efficiency of the boiler will be less than ½ lb. of water per pound of coal. It is also somewhat of a surprise to find that the increase in pressure has very little effect on the smoke-box temperature, and that an increase of 100% of the former resulted in only 3½% increase in the latter. Numerous diagrams are here introduced showing the ratio of evaporation and the draft in the smoke-box, as well as proportion of CO obtained under the different conditions of operation.

The chapter on engine performance which follows is rendered unique by the very beautiful method of illustrating the effect of speed and cut-off variation on the indicator diagram. The various runs under each pressure are represented by typical indicator diagrams, to small scale, it is true, but still very effectively, and these show at a glance the variation of cylinder performance, due to changes either in speed or to cut-off. We believe that this presentation is absolutely novel, and it is certainly a most interesting and instructive one. For the benefit of those who desire to study the diagrams closer, the important ones are given to full scale at the end of the book. The indicated horse-power and the steam consumption per horse-power hour are made the subjects of additional diagrams and their relation to that which might be expected from a perfect engine is illustrated by means of a diagram which many of us will remember was first shown by Dr. Goss at a meeting of the Master Mechanics' Association several years ago.

At the close of this chapter the results in steam and coal economy of increasing pressures are shown, both by table and corollary. This presentation is very impressive and should settle many disputes as to the advantages of higher boiler pressures.

Machine friction and performance at drawbar are given several pages, and the best cut-off for different boiler pressures is determined, considering the amount of steam used per dynamometer horse-power. As would be expected, this point of cut-off is later in the lower pressures than in the higher, and while of course in actual practice a locomotive using high pressure would have a cylinder of smaller diameter than for an engine with lower pressures, this was impossible of accomplishment under the conditions of these tests.

Chapters 6 and 7 treat of boiler pressure and boiler capacity, respectively, as factors in economical operation; and Chapter 8 draws conclusions upon the advantages of increasing pressure or capacity. These three chapters represent the main burden of the task: that is, to show what is gained by higher pressures, and where pressure and capacity can be advantageously substituted the one for the other. The diagrams showing the benefits obtained by increase in pressure and increase in capacity, due to a certain allowable increase in weight, are of particular interest, and tell us that while with low pressures we have much to gain in economy, by increasing the pressure to a certain amount, when we reach a higher figure, we will be better benefited by increasing the *capacity* of the boiler, providing, of course, we are limited to a certain increase in weight. It is claimed, also, that under ideal conditions either the pressure or capacity may be increased with equal advantage at 200 lbs. initial, and that no possible excuse can be found for increasing the pressure above 220 lbs. It must be borne in mind, however, that these deductions, as stated in the preamble, were for single expansion locomotives only.

The appendix contains illustrations of locomotive No. 2 and the various data obtained from the individual tests, the latter comprising 30 pages alone. The illustrations are clear, but the printer has placed some of them upside down, notably Fig. 91 and a portion of Fig. 120. These are obvious, however, at a glance. The methods of conducting the tests are given in complete detail, showing all the items which were taken and the method of figuring the indirect values, and an index of six pages enables one to find

*Consulting Engineer, 20 West 34th St., New York City.

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An Engineer and a River.

THE RIVER IRWELL.—Pleasant Reminiscences of the Nineteenth Century and Suggestions for Improvements in the Twentieth. By J. Corbett, Borough Engineer of Salford, Manchester, Eng.: Abel Heywood & Son, London: Simpkin, Marshall, Hamilton, Kent & Co., Ltd. Cloth; 5½ × 8¾ ins.; pp. 155; 59 plates.

In his introduction the author states:

When I was elected a member of the Salford Town Council in August, 1887, the only unusual pledge that I gave the electors was that I would endeavor to promote the improvement of the Irwell, so that it might be again as comparatively pure as I had known it when a boy; and it has been my good fortune, as a member of the Salford Council for five years, and afterward for fifteen years as Borough Engineer, to take some share in effecting the great improvement made within recent years.

In preparing his interesting book on the River Irwell, Mr. Corbett has first described the river and interesting objects connected with it, beginning opposite the cathedral in Manchester, going down the river to Runcorn and then back on the other side, "commenting on each bridge, wharf, warehouse or other feature deserving notice, and giving special attention to the attractions of the river 50 to 70 years ago." He then takes in like manner the upper part of the river to the junction of the three small streams which form it. He also diverges from the river proper to some of the canals and tributaries associated with it. A large amount of interesting information is thus given, accompanied by many handsome reproductions of photographs and some reproductions of old prints. A number of incidents relating to engineering and allied subjects are given, particularly notes on bridges and on the part taken by the author in the improvement of lifeboats.

Considerable space is given to rowing and rowing clubs, with some of which the author appears to have been intimately connected, and there is a brief chapter on fishing—which, by the way, he says he has not indulged in since he was a boy.

Of particular interest to engineers will be the chapters dealing with floods and their prevention, and the various means that have been taken for preventing the pollution of the river. As to flood prevention, the author has worked out a scheme for a tunnel 28 ft. in diameter and about half a mile long, to divert flood waters from a contracted portion of the river channel within the city.

The author, as some of our readers well know, built and has for many years successfully operated one of the most notable sewage purification plants in England, including the first large-scale installation of percolating filters supplied with fixed sprinklers or jets.

DECORATION OF METAL, WOOD, GLASS, ETC.—A Book for Manufacturers, Mechanics, Painters, Decorators, and all Workmen in the Fancy Trades. Edited by H. C. Standage, Consulting Chemist. New York: John Wiley & Sons. London, Eng.: Chapman & Hall, Ltd. Cloth; 4½ × 7½ ins.; pp. 228. $2, net; English price, 8s. 6d., net.

As the title of this book indicates, it is full of directions for bronzing and coating and staining metals, fixing drawings, dyeing, enameling, glass sign painting, gilding and silvering, etching, decorating books, china and glass, lacquering and japanning, polishing and staining wood, and other things of like sort. It can be seen that it contains information which should give it a wide field of usefulness.

WOOD.—A Manual of the Natural History and Industrial Applications of the Timbers of Commerce. By G. S. Boulger, Honorary Professor of Natural History in the Royal Agricultural College, Author of "Familiar Trees," etc. Second Edition, revised and enlarged. London, Eng.: Edward Arnold. New York: Longmans, Green & Co. Cloth; 5¼ × 8¾ ins.; pp. 348; 48 plates and 43 text illustrations. $4.20, net.

The first edition of this useful book was favorably noticed in our issue of Nov. 12, 1903. As we there stated, it is a handbook of the commercial woods of the world. In addition it contains general information on woods, their classification, defects and uses, together with a review of the wood supplies of the world and a section on wood testing.

There is no preface to the present edition, nor any ready means of telling how extensive the revision has been. Apparently, however, the revision is confined chiefly to the insertion of notes, some of which refer to information of quite recent date.

Earthwork Tables.

PRACTICAL EARTHWORK TABLES.—By C. E. Housden, Superintending Engineer P. W. D. India. New York and London: Longmans, Green & Co. Cloth; 4¾ × 7¼ ins.; pp. 49; nine plates. 90 cts., net.

Either the publishers of earthwork tables are not very enterprising in sending copies of their books to such far countries as India or the author of the latest of these tables has not profited by observation, for his book is inferior in design and application to most of the dozen or more earthwork tables now in print. The tables are for the computation of areas alone; the volumes for station distances are to be computed by any of the several formulas in use, so they are limited at the start to a small field. These areas are tabulated under various side slopes, from 2 on 1 to 1 on 8, for depths varying by tenths from 0.1 ft. to 70 ft. The areas are all for horizontal ground, so that for any slope or multiple level the section has to be divided into smaller areas which can be determined from the table. The multiplication and addition necessary to convert the small units for level ground given in the table to the total area or total volume per station is in no way shorter or more correct than the ordinary geometric computation. The following sentence in the book does not show much confidence in his work on the part of the author:

The areas above obtained [by use of the tables—Ed.] can of course be also ascertained from formula VI. [the ordinary geometric formula for a trapezoid section—Ed.] and it is always advisable to check results from the tables by so calculating them; a double check on work is thus secured.

The explanations accompanying the tables are the work of a man who is so thoroughly acquainted with the process of using the tables that he cannot take the viewpoint of one approaching them for the first time; consequently the methods of applying the tables are very obscurely stated.

STATE SEWERAGE COMMISSION (New Jersey).—Report to the Legislature of 1908. (Charles W. Fuller, Chairman.) Jersey City, N. J.: The Commission. Cloth; 5½ × 9 ins.; pp. 390.

During the year covered by this review the Commission named made investigations and reports on a large number of sewage purification plants in the State, either by the agency of its own members or by engineers employed for the purpose. Besides routine reports on the work of the Commission proper, the volume contains a special report by Professor Earle B. Phelps, of the Massachusetts Institute of Technology, on disinfection of a septic tank effluent at Red Bank, N. J., a report by Mr. George W. Fuller, of Hering & Fuller, M. Am. Soc. C. E., New York City, on the operations of the Plainfield sewage works and a report by Mr. George C. Whipple, Assoc. M. Am. Soc. C. E., of Hazen & Whipple, New York City, on gas-works wastes. There are also a number of other special reports by engineers.

COMMISSION ON STREET CLEANING AND WASTE DISPOSAL, THE CITY OF NEW YORK.—Report, 1907. Commissioners, H. de B. Parsons, Rudolph Hering, Samuel Whinery. Paper; 6¾ × 10¼ ins.; pp. 241; diagrams and tables.

It would not be far out of the way to call this a manual of street cleaning and city waste disposal, although the report was of course written primarily from the local viewpoint of New York City. An extended abstract of the report will soon appear in Engineering News.

AMERICAN CERAMIC SOCIETY.—Transactions, Vol. IX. Containing Papers and Discussions Read at the Meeting Held at St. Louis, Mo., Feb. 4-6, 1907, Together with Some Other Contributions Sent in Subsequently. Columbus, O.: The Society (Edward Orton, Jr., Editor). Paper; 6 × 9 ins.; pp. 808; illustrated.

While appealing more particularly to specialists in pottery and ceramics, the annual report of the American Ceramic Society contains some papers on the behavior and manufacture of brick which may prove of value to the engineer.

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